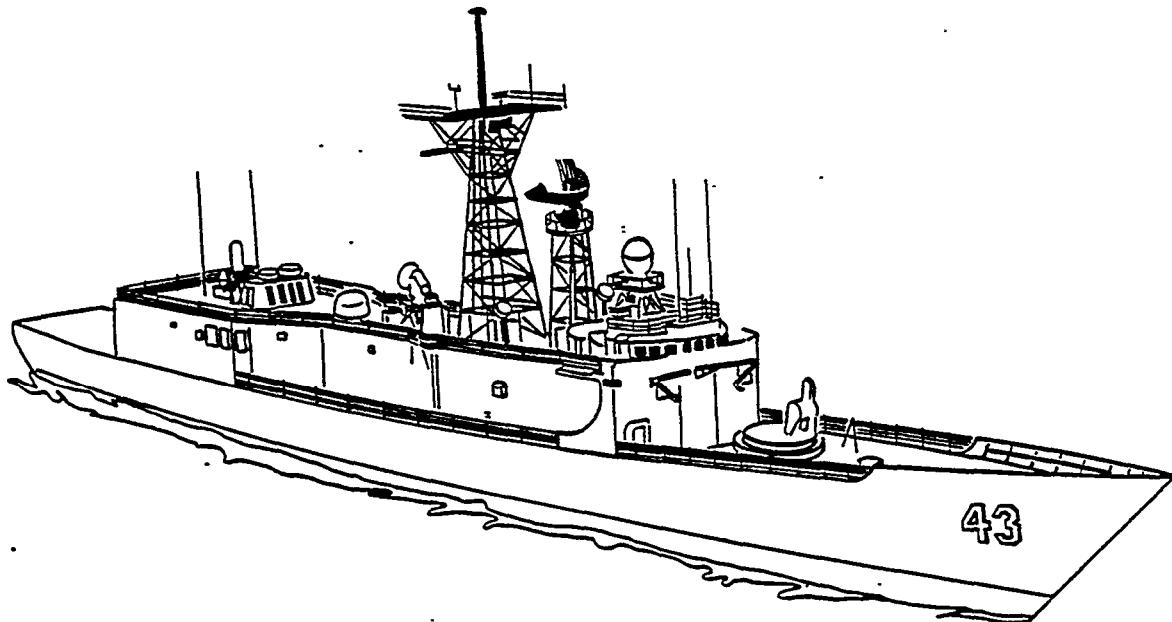


INTERFACE IMPACTS SYSTEM TO ZONE TRANSITION



Prepared by:

**TODD SHIPYARDS CORPORATION
LOS ANGELES DIVISION
SAN PEDRO, CALIFORNIA**

a Project of

**THE NATIONAL SHIPBUILDING RESEARCH
PROGRAM**

by

**THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
SHIP PRODUCTION COMMITTEE PANEL SP-4
DESIGN/PRODUCTION INTEGRATION**

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This report documents the results of a study performed for the National Shipbuilding Research Program, a cooperative effort of the Maritime Administration, the United States Navy, the Society of Naval Architects and Marine Engineers, and the U.S. shipbuilding industry.

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1.0 BASIS OF THIS STUDY

1.1 INTRODUCTION

The productivity of the U.S. commercial shipbuilding industry has been analyzed and established as approximately half that of the leading foreign competition. (1) In contrast, the productivity of the U.S. naval shipbuilding industry is not well documented. The methods used in constructing naval combatant ships also must be analyzed and evaluated so efforts to improve productivity therein can be focused on specific problems and opportunities.

Much has been written about the Ishikawajima-Harima Heavy Industries (IHI) System, which includes:

- 1) Detailed Production Planning
- 2) Product Work Breakdown Structure
- 3) Zone Outfitting Method (ZOFM)
- 4) Process Lanes
- 5) Accuracy Control

The transfer of this technology is directed generally towards commercial shipbuilding. Naval shipbuilding has constraints which are very different from those of commercial shipbuilding. These constraints have an important impact on developing producibility improvements during the design process and the construction of a naval ship. Some of these constraints are:

- 1) Change Control
- 2) Planning Work-arounds for Scheduling or Testing Constraints
- 3) Government Furnished Material Availabilities
- 4) Cost/Schedule Control System Requirements

Todd Shipyards Corporation, Los Angeles Division (TLA), made a number of analyses commencing in 1981 to find out how to best improve productivity. This was done by studying IHI.principles, reviewing our facilities planning, the capabilities of our equipment, and manpower breakdowns. This led to Todd's decision to implement Zone Outfitting Methods (ZOFM). Using a combination of techniques suitable for our yard, TLA implemented ZOFM in the middle of the FFG-7 Class construction program starting with U.S.S. Thach, FFG-43. the 12th of an 18 ship building program. Percentages of completion at launch rose markedly as a result of ZOFM as shown on Figure 1.1.1. These gains, moreover, were obtained while maintaining the original launch dates. This higher degree ,of completion leads, logically. to reduced time from launch to delivery. (See Figure 1.1.2).

Operational considerations, i.e., manning shifts, equipment availability and/or launch considerations caused the minor variations among the ships deliveries even after ZOFM was implemented. These variations are essentially unrelated to the production and scheduling improvements ZOFM made possible.

1.2 DEVELOPMENT

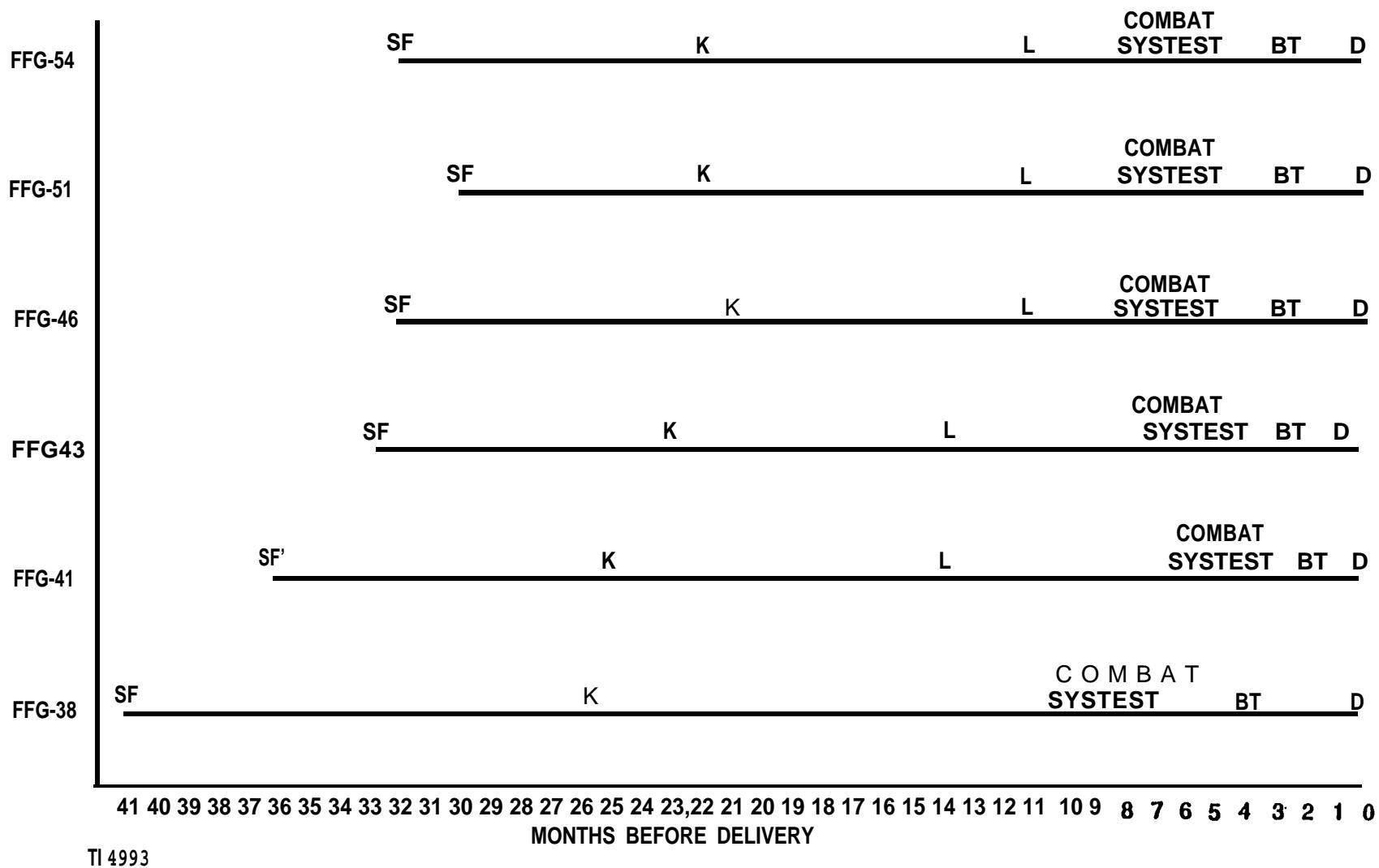
The original approach in this study was to perform an analysis of selected areas of an FFG-7 Class frigate, a midsized surface combatant, to identify and quantify the significant impacts of ZOFM on the production process at Todd Shipyards Corporation, Los Angeles Division (TLA). The goal was to compare actual production information from an early ship (FFG-19) constructed in accordance with conventional shipbuilding methods to a more recent ship constructed using ZOFM.

3

SHIP IDENTIFICATION		PERCENTCOMPLETE ATLAUNCH (COSTGROUPS 100 THROUGH 700)	LAUNCHDATES		DELIVERYDATES		
HULL NUMBER	NAMES	PHYSICAL COMPLETION	CONTRACT	ACTUAL	CONTRACT	CMPLT	WEEKS EARLY
FFG-38	CURTIS	44%	03/06/82	03/06/82	09/02/83	07/22/83	6
FFG-43	THACH	57%	12/18/82	12/18/82	04/20/84	02/09/84	11
FFG-54	FORD	66%	06/23/84	06/23/84	09/06/85	05/31/85	14

TI 5010

FIGURE 1.1.1 COMPLETION COMPARISONS



LEGEND

SF START FABRICATION
 K KEEL LAYING
 L LAUNCH
 BT BUILDER'S TRIAL

FIGURE 1.1.2 SCHEDULE COMPARISON

As we gathered statistics it became apparent that:

- 1) The comparison of the statistics from FFG-19 and a recent ship would result in analyzing data from ships that were on either side of a major design change in which the stern of the ship was extensively modified. This was done so the later ships could accept the larger LAMPS III helicopter. This would distort the comparison figures.
- 2) The records kept on the production performance of FFG-19, to the degree required for this study, were not in our data bank. The effort required to retrieve the records needed from the archives of the individual production departments, moreover, would have been economically undesirable.
- 3) It would be advisable to include the statistics of the ship involved with the first attempt at ZOFM construction in addition to a pre-ZOFM ship.
- 4) Limiting the study to the comparison of only selected areas of FFG's turned out to be impractical because our Cost/Schedule Control System (C/SCS) was set up for cost collection by systems for the early FFGs and for cost collection by Zone for the later FFGs.

1.3 SCOPE

The study was consequently revised in view of the above development to allow for the investigation of those ships providing the most meaningful data. Case studies were therefore conducted of a conventionally constructed FFG-7 Class frigate, a FFG at the center of the transition period

to ZOFM and a recently constructed ZOFM ship of the same class. The purpose of identifying and quantifying the impacts of the ZOFM on the production process at TLA remained the same.

The ships now targeted for this study were the FFG-38, FFG-43 and FFG-54, the 10th, 12th and 15th ships, respectively, of this class constructed at TLA.

The FFG-38 was selected to represent a ship constructed, prior to ZOFM implementation, as it was the first ship after the stern modification was incorporated and was two ships earlier than the start of ZOFM construction. FFG-43 was selected since it was the first ship to have ZOFM applied to construction, and FFG-54 was chosen as the most recently completed ship at the start of this study.

It was also decided to compare ships as a whole instead of just selected areas of the ships.

1.4 APPROACH

An experienced and well rounded team of engineers, planners and production managers was selected to thoroughly analyze and document the before and after conditions at TLA. The team was made up of senior and middle department managers associated with TLA's FFG program from its inception. The project team was to look objectively at the process of ship construction and identify the impact of the changes on the overall productivity. Members of the team were also to determine the sources of the problems arising from the changeover to advanced outfitting and the recommended solution.

e tasks required by this study were:

- 1) Gathering the statistics for FFG-38, FFG-43 and FFG-54.
- 2) Analyzing the statistics to identify the data applicable to this study.
- 3) Comparing the facts and figures to identify the impact of the transition from system oriented construction to ZOFM construction.
- 4) Normalizing manhours and costs to protect proprietary data while keeping the information and the comparisons intact.
- 5) Gathering representative photographs and work sketches and developing the graphs and tables.
- 6) Preparation and writing of the report.

The departments impacted by the transition to ZOFM are listed on Table 1.4.1. This table provides a cross reference of the department numbers used in this report and the related department functions.

<u>DEPARTMENT</u>	<u>FUNCTION</u>
Dept. 1	Shipfitters
Dept. 2	Joiners/ShipWrights
Dept. 3	Sheetmetal
Dept. 6	Marine Machinists
Dept. 8	Pipefitters/Coppersmiths
Dept. 9	Electricians
Dept. 41	Painters
Dept. 42	Laborers
Dept. 54	Management Information Services (MIS)
Dept. 67	Safety
Engineering Dept. 70	Scientific and Planning Section
Planning Dept. 72	Work Orders and Schedules
Dept. 77	Test and Trials

TABLE 1.4.1

1.5 BACKGROUND

The full scope of the impacts to TLA during the transition period of this study must be viewed against the TLA production policy in existence prior to that transition.

The San Pedro yard was founded in 1917 and had built or converted 124 commercial and Navy vessels of various types and sizes. In 1975, TLA actively reentered the new construction/conversion field following a post World War II shipbuilding lag, and the building ways were renovated prior to the start of the FFG-7 Class frigates.

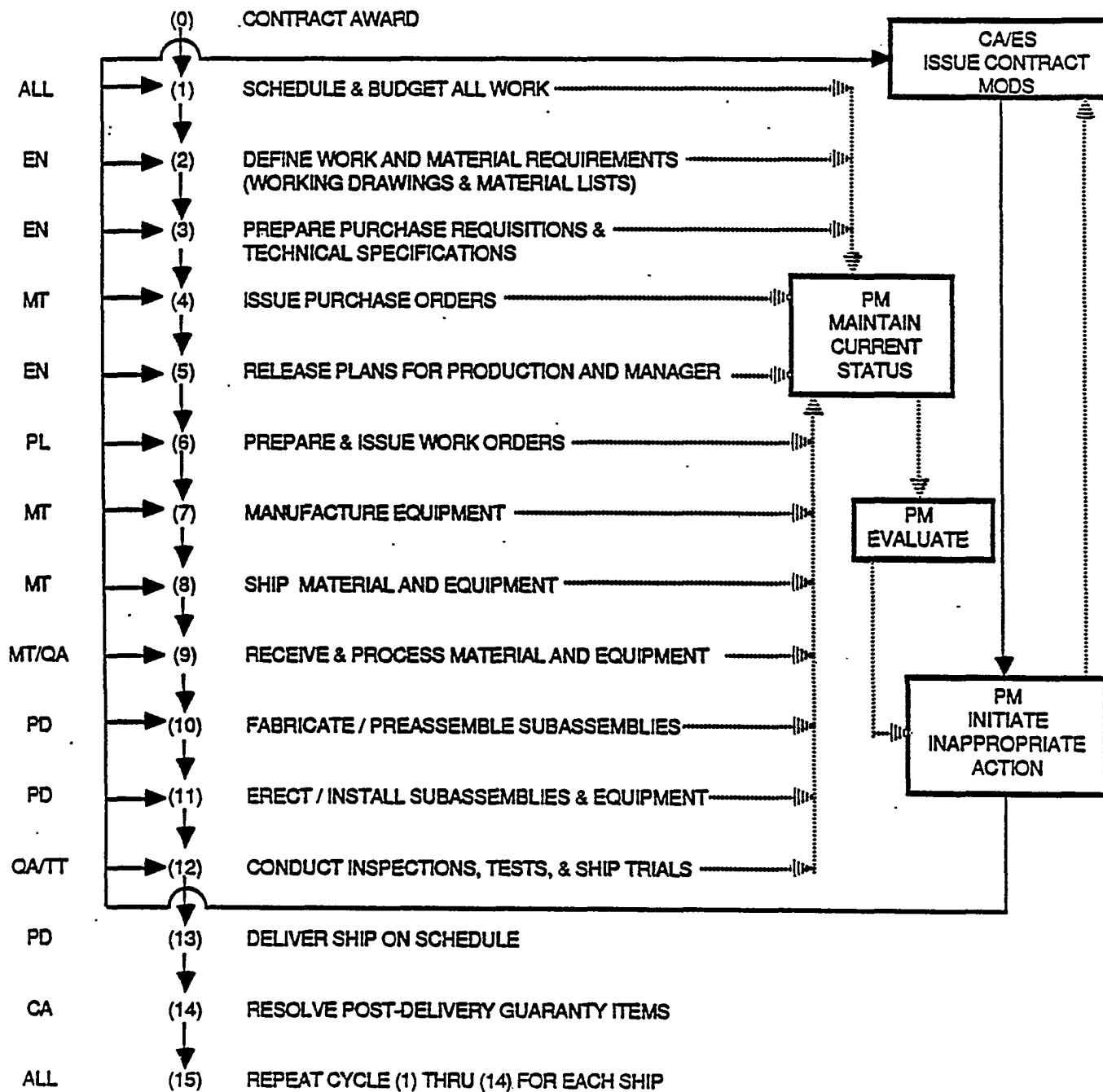
Figure 1.5.1 is a copy of the new construction activity flow chart in practice prior to the implementation of ZOFM construction. This flow chart was part of a presentation made by Todd management to the Los Angeles Metropolitan Section of the Society of Naval Architects and Marine Engineers. This presentation(2) described, in part, the procedures for satisfying the contractual and construction requirements of the FFG program. At the time of the authorization to proceed with the FFG contract, the project activities shown were successively broken down to more detailed schedules. Drawing release and material ordering schedules were prepared and made compatible with the Master Erection Schedule by an iterative process.

In the months immediately following the award of the follow ship contract for the FFG's, the validated distributive system drawings were rarely available. Dwindling production activity resulting from the near completion of a four ship tanker construction program nevertheless made Todd management anxious to proceed in spite of the lack of drawings needed

(2) E. J. Petersen and L.M. Thorell. A Shipyard Management Challenge: Do Repair and New Construction Really Mix? Los Angeles Metropolitan Section of the Society of Naval Architects and Marine Engineers, 10/79

RESP'Y

ACTIVITY



LEGEND

PM - PROJECT MANAGEMENT
ES - ESTIMATING
CA - CONTRACT ADMINISTRATION
QA - QUALITY ASSURANCE

PD - PRODUCTION
PL - PLANNING
TT - TEST & TRIALS
EN - ENGINEERING
MT - PURCHASING & MATERIAL CONTROL

FLOW

→ ACTION
—> INFORMATION

FIG. 1.5.1 TODD L.A. DIV PRE-ZOFM PROJECT CONTROL FLOW CHART
(NEW CONSTRUCTION)

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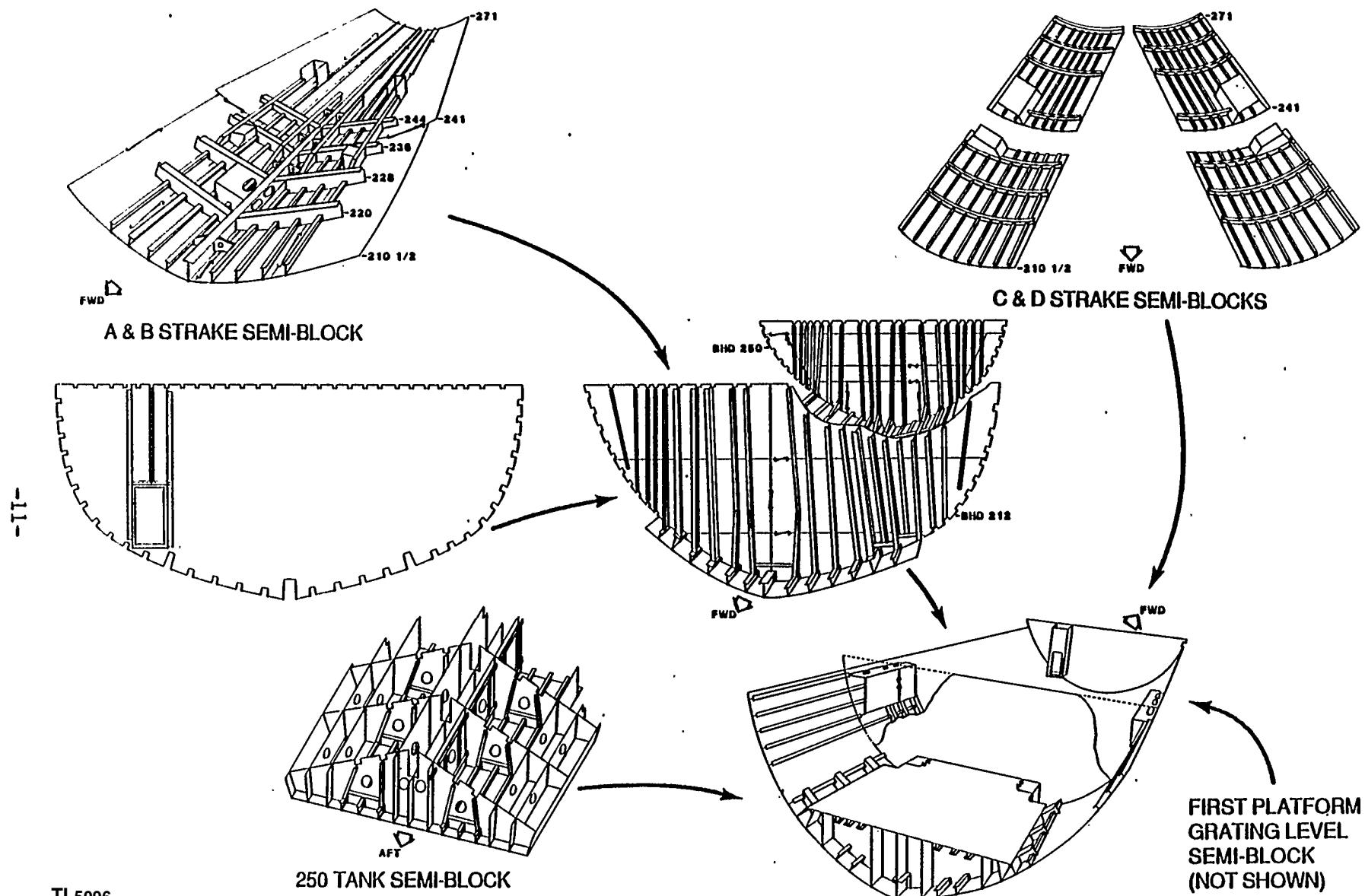
for pre-outfitting. The decision to proceed was therefore made at a calculated risk. Although Todd had planned, even during that era of conventional shipbuilding to outfit blocks to the fullest extent possible, it was decided to construct and erect the hull first. The ship then would be outfitted subsequently. The gamble was that the validated outfitting drawings would arrive in time for this. That particular gamble paid off as we met the delivery date. But the mold was set.

With other ships following on immediately, and with our manning now committed to the above construction sequence, it became very difficult to phase back to outfitting on block. Breaking out of this mold increasingly became one of our major concerns.

Another area of concern was the equipment receipt dates (either sub-contractors, vendors or for Navy furnished material). The emphasis on erecting the hull first as noted earlier also set the pattern in establishing the equipment need dates to suit. This set pattern was more difficult to readjust to the on-block outfitting needs than the manning.

A third concern was the availability of the expanded facilities which surfaced at the time of the transition to ZOFM construction. The existing facilities moreover had already been arranged to suit the hull construction methodology.

Figure 1.5.2 is offered as a typical construction method of the era. Note that this construction was being accomplished without the benefit of on-block outfitting. The increased difficulty in outfitting as the block is closed in is easily visualized.



TI 5096

FIGURE 1.5.2

1.6 THE DECISION TO CHANGE

A number of factors ultimately were involved in the decision to implement ZOFM construction. Generally, however, the driving factors were the need to maximize the efficient use of personnel, streamline the flow of material and allow the most efficient use of the facilities. This really can be reduced to one overriding goal...remain competitive to the increasingly tightened shipbuilding market.

ZOFM design and construction was clearly the way for gaining these time and cost efficiencies through the maximum preoutfitting of the ship. These efficiencies are only possible, however, through the additional efforts placed on the planning, engineering and material, procurement functions.

As previously mentioned, TLA was experiencing difficulty in gradually phasing into ZOFM. Todd management decided therefore the only way to go to ZOEM was to implement it 100 percent in the construction of the FFG-43. It realized there was a potential risk of disrupting the FFG program in so doing, but was confident it could more effectively solve the problems associated with implementing ZOFM in this learn-by-doing manner than by gradually doing so. The problems management had to work out included craft coordination, work sequences, material kitting, rewriting the work packages and revamping the cost and schedule control system.

1.7 SUMMARY

This study is presented as an example of impacts incurred by the implementation of ZOFM construction under the type of conditions particular to the Los Angeles Division of Todd Pacific Shipyards.

This report therefore also describes Todd's background, our areas of concern, the ships being compared, and our specific reasons for changing to Z0FM construction.

It should be noted that the tracking of the cost and schedule reports of the ships being constructed at the time of this report are showing significant savings; and it is apparent that the effort and perserverance expended during TLA's transition period is now being rewarded.

2.0 EVALUATION OF STATISTICS

2.1 CRAFT IMPACT ANALYSIS

2.1.1 APPROACH TO ZOFM IMPLEMENTATION AT TLA

The approach taken during the construction of FFG-43 is illustrated by the flow chart on figure 2.1.1.1 as compared to the conventional method of ship construction used prior to the implementation of ZOFM as described in the previous chapter. The description of the terms shown on this chart are as follows:

<u>TERM</u>	<u>DESCRIPTION</u>
Structural Preparation	<ol style="list-style-type: none">1) Shot blast and paint raw material2) Cut material into parts3) Shape applicable parts
Sub-Assembly	<ol style="list-style-type: none">1) Part assembly2) Sub-block assembly3) Semi-block assembly (to include flat panels and curved plates)
Unit Assembly	<ol style="list-style-type: none">1) Semi-block assembly (to include portions of units such as single deck & its bulkheads)2) Block assembly
Phase 1 Outfitting	<ol style="list-style-type: none">1) All hotwork attachments to the hull structure2) Example shown on figure 2.1.1.2
Phase 2 Outfitting	<ol style="list-style-type: none">1) Equipment, machinery and furniture, and such other material which might be damaged by the blasting and painting of the block following its assembly.2) Example shown on figure 2.1.2

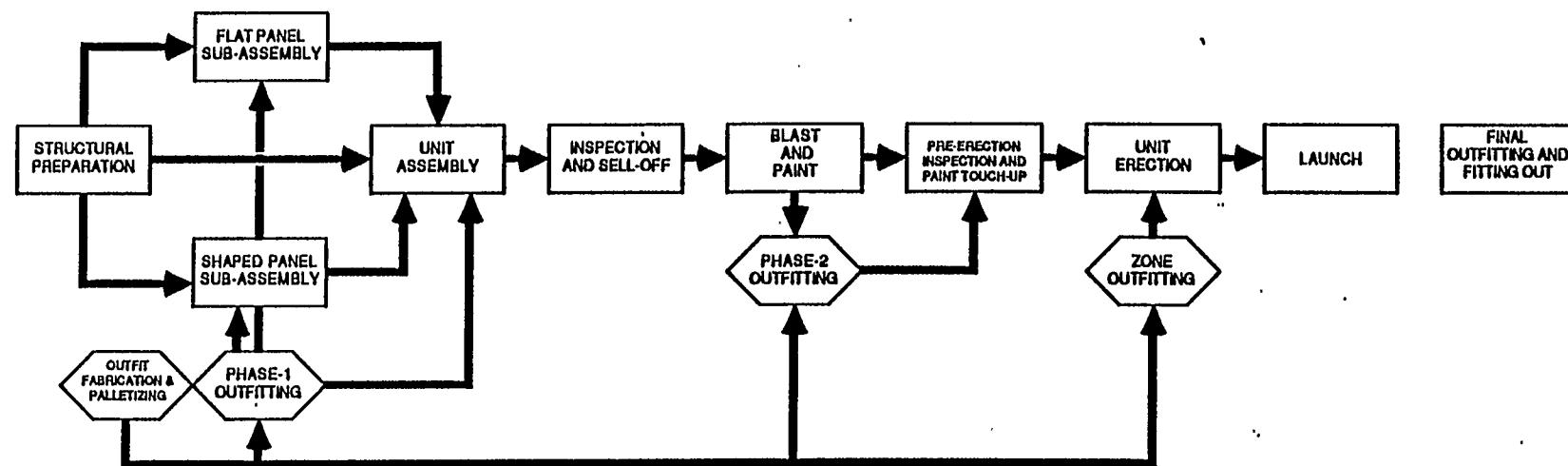
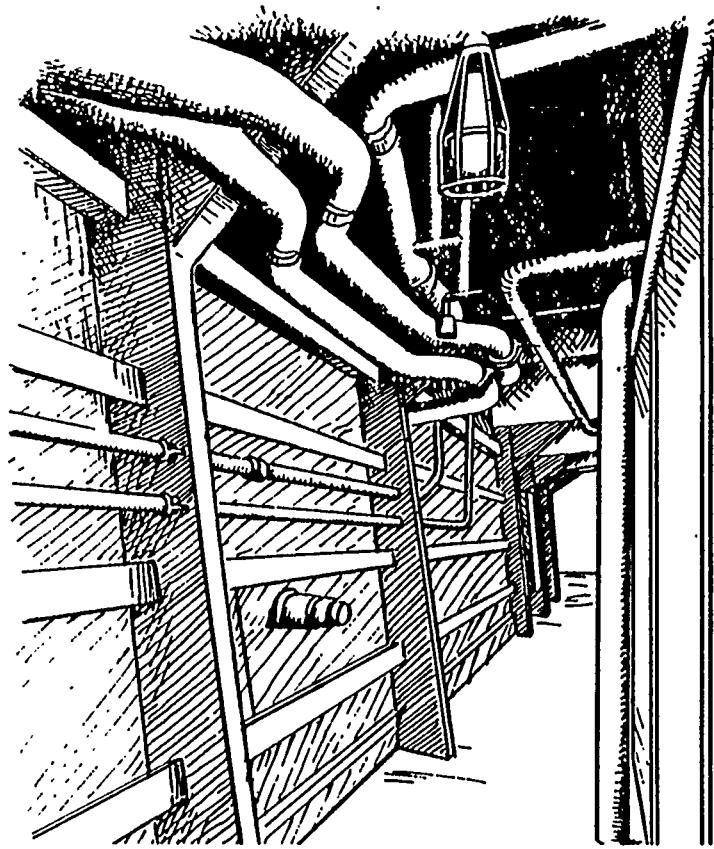
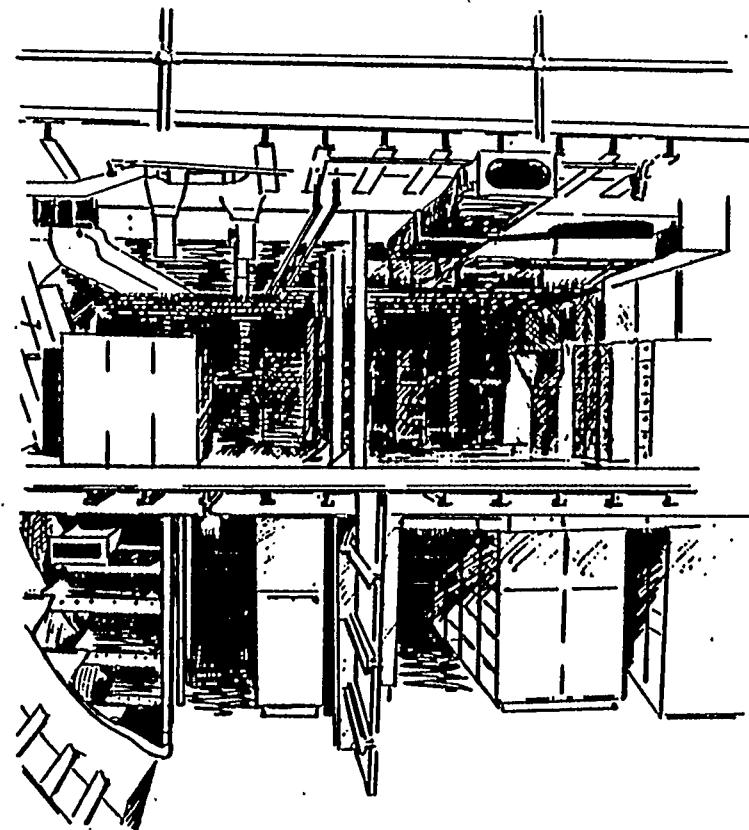


FIGURE 2.1.1.1 CONSTRUCTION APPROACH OVERVIEW



TI 4007

FIGURE 2.1.1.2 PHASE-1 PRE-OUTFITTING



TI 4006

FIGURE 2.1.1.2 PHASE-2 PRE-OUTFITTING

<u>TERM</u>	<u>DESCRIPTION</u>
zone Outfitting	1) Outfitting performed at erection joints after block erection
Final Outfitting and Fitting Out	1) Originally planned to be the outfitting restricted to after launch.(i.e. battery alignment, combat equipment loading, etc.) 2) Loading of perishables and pilferables

The degree to which the crafts followed this plan is discussed in Section 2.2 through 2.12.

2.1.2 CONSIDERATIONS OF IMPACT ANALYSIS

The decision to use the FFG-54 for the study in retrospect resulted in the data being somewhat skewed, again for reasons outside of the potential gains obtainable with ZOFM.

The FFG-54 was chosen to represent the most recently constructed ship at. TLA. The FFG-57 completed after the study might have provided more meaningful data. This is because:

- 1) FFG-54 was erected on Ways #2 where the lifting capacity is considerably less. This affected the amount of preoutfitting that could be accomplished. Section 2.11 further explains the impacts involved with the difference in the lifting capacities. FFG-57 was built on Ways #1. Had it been used in this study, the analysis would have been simplified. As it is, the analysis in the following sections had to be adjusted as much as possible for the difference in the costs due to the weight restrictions on Ways #2.

2) During the period of the construction of FFG-54, TLA was anticipating the award of a major new contract. Therefore, the manpower which normally would have decreased with the fewer number of FFGs to build was retained. This caused an otherwise unnecessary front loading of the manning for FFG-54.

Figure 2.1.2.1 shows the overall comparative labor costs (cost groups 100-700). This graph illustrates the above points as it shows that the FFG-54 costs came in at or above the costs of the earlier FFG-43 on which ZOFM was first implemented. It should be noted that the costs for FFG-57 were significantly lower as indicated by the phantom lines in the subtotal column because of more efficient manning and the learning curve effects.

The following sections address, for the most part, the primary impacts experienced by the crafts. The exceptions are the Departments 54, 67, 70, 72 & 77, (see Table 1.4.1) which experienced what can be referred to as secondary impacts. Cost groups 800 and 900 on Figure 2.1.2.1 generally represent planning and support activities respectively (including supervision), respectively.

The transformation from the conventional construction methods to ZOFM, as shown on the graph, provided a cost reduction across the board. It was not until after the actual transformation of the production process was effected that TLA started catching up in the planning stages.

The sections of this report on TLA's Management Information Services, Engineering and Planning delve into these impacts which occurred at about the half-way point between FFG-43 and FFG-54. By the time the FFG-54 costs were being collected, the planning and support activities were heavily involved. This is why the total costs on the graph show a temporary increase in costs.

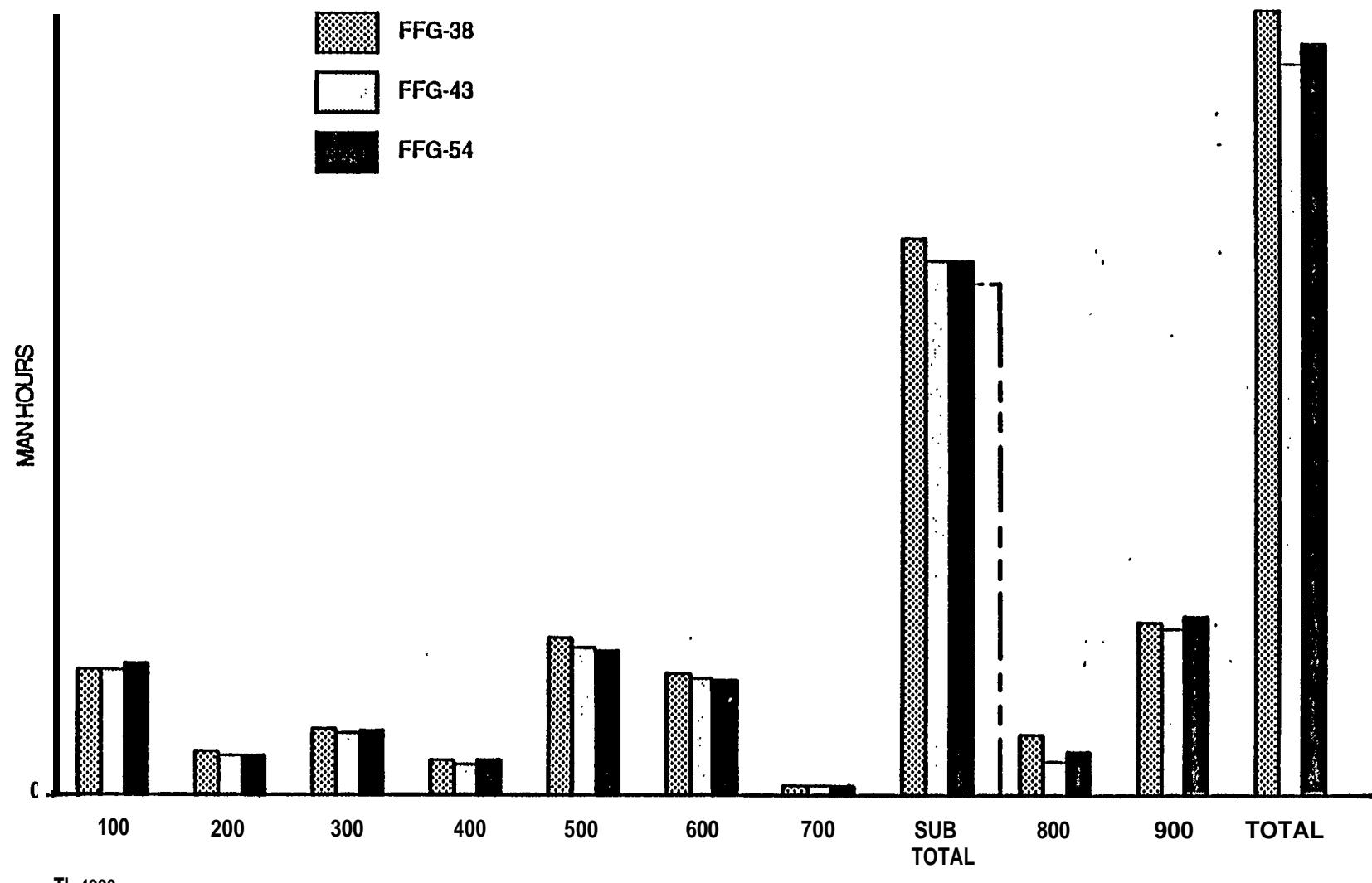
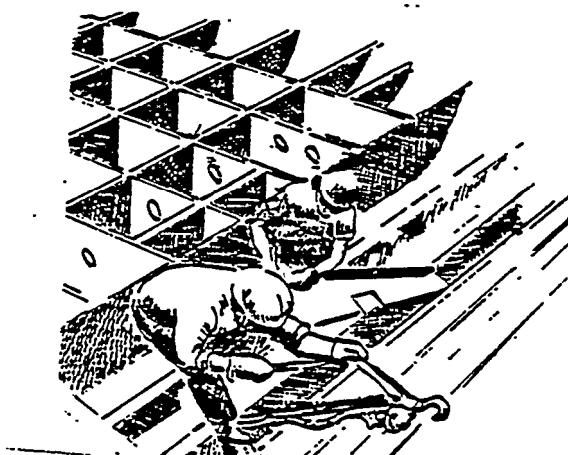
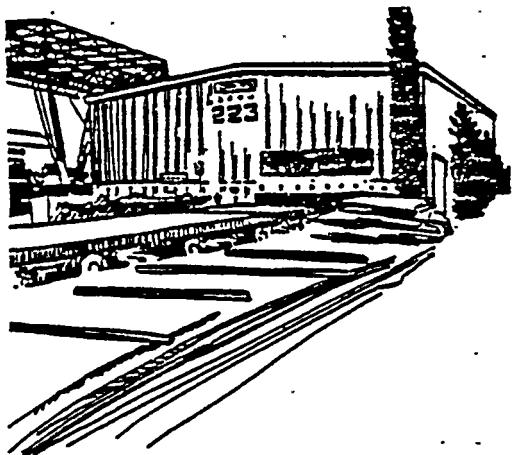


FIGURE 2.1.2.1 ALL DEPARTMENTS

2.2 SHIPFITTING/DEPT. 1

The shipfitters probably felt the impact of the transition from system to zone outfitting the most severely as it previously had the least interaction with the other crafts.



Prior to ZOFM construction, the hull units were constructed with little or no outfitting prior to their erection. The Shipfitting Department thus had little need to coordinate its activities with the other crafts. Factors requiring rethinking and close attention to avoid adverse cost increases or scheduling delays included the following:

- 1) Rework on already fabricated structural subassemblies not as yet installed so as to accommodate outfitting advances. This required the partial disassembly of these structural elements to fit them around the installed outfitting.
- 2) Increases in the manhours needed to accomplish a work order when the job was already manned but the work was delayed slightly by the presence of other crafts working in the same area.

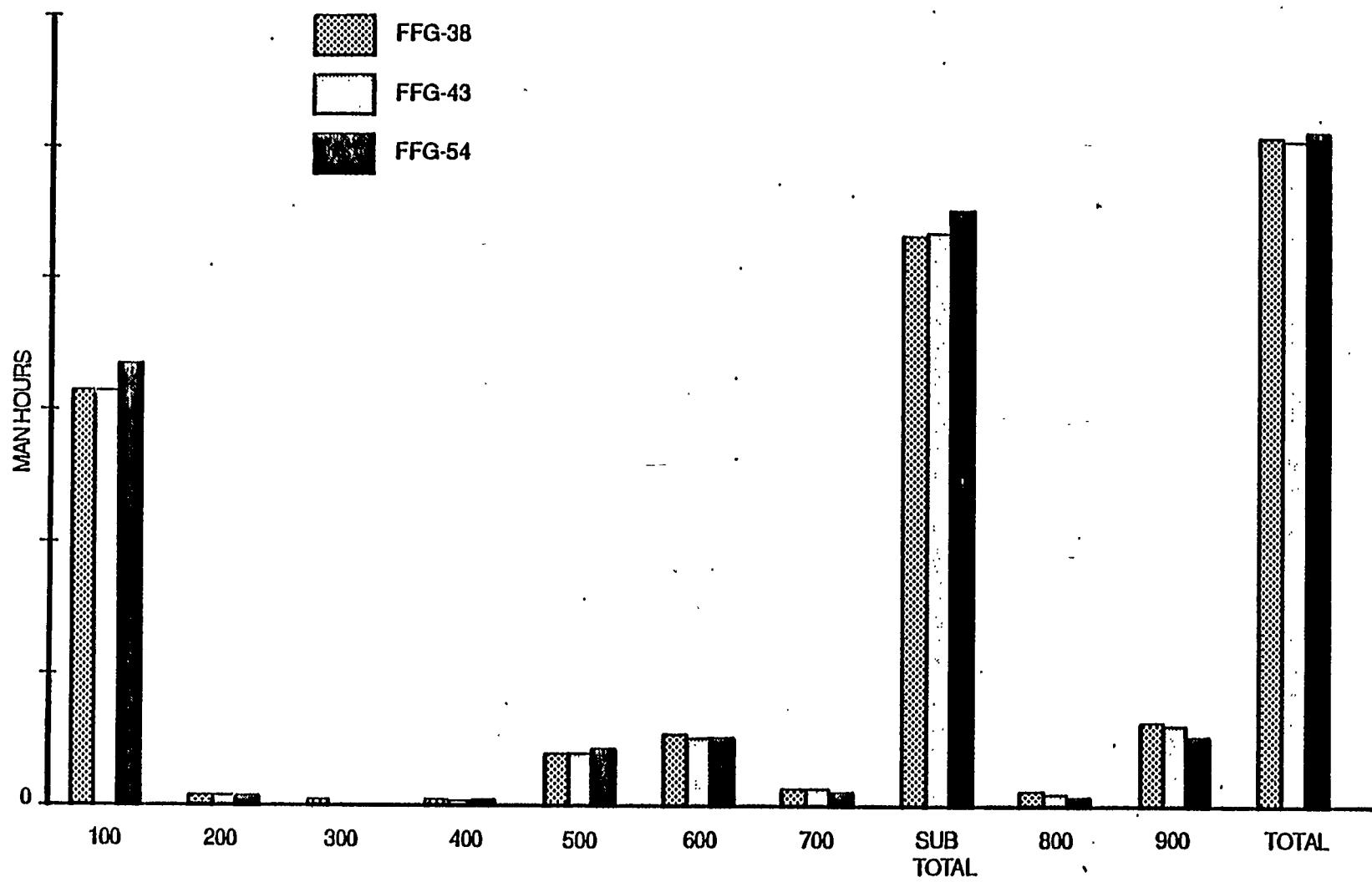
- 3) Increases in manning on premium shifts or working overtime to alleviate the complications of congested working areas.

Consider Figure 2.2.1. Cost group 100 is the area in which the Shipfitter Department is mostly involved. Little change in costs were evident during the construction of the first ship to undergo on-block outfitting (FFG-43). This is because the decision to start ZOFM construction came at the time that the shipfitters were well underway in the construction of this ship and did not experience a great deal of interference with other crafts.

The manning as shown on Figure 2.2.2 did peak higher for FFG-43, but Department 1 started later than on FFG-38 and completed earlier.

The manning comparison shows that FFG-54 on the other hand was started early for operational considerations outside the purview of this study, i.e. the need to meet program milestones and/or avoid costly layoff/recall cycles. The down side of the FFG-54 graph, on the other hand, follows closely the data on the other ships. Department 1 did finish-earlier on FFG-54 than the other ships. The reduced manning in this period, however, is normal for this time frame whereas the early start was done with an increase of manning, resulting in the higher overall manhour cost.

Figures 2.2.3 and 2.2.4 show the hull structure erection functions separately. The manhours for each successive phase of construction of the hull on the later ships generally increased. The preparation phase (cost account 100) in general is an exception to this. That is, the FFG-43 shows a normal learning curve as preparation activities are not affected by interference from outfitting crafts. FFG-54, however, shows a slight rise in accordance with the before-mentioned early start.



TI 4979

FIGURE 2.2.1 DEPARTMENT 01

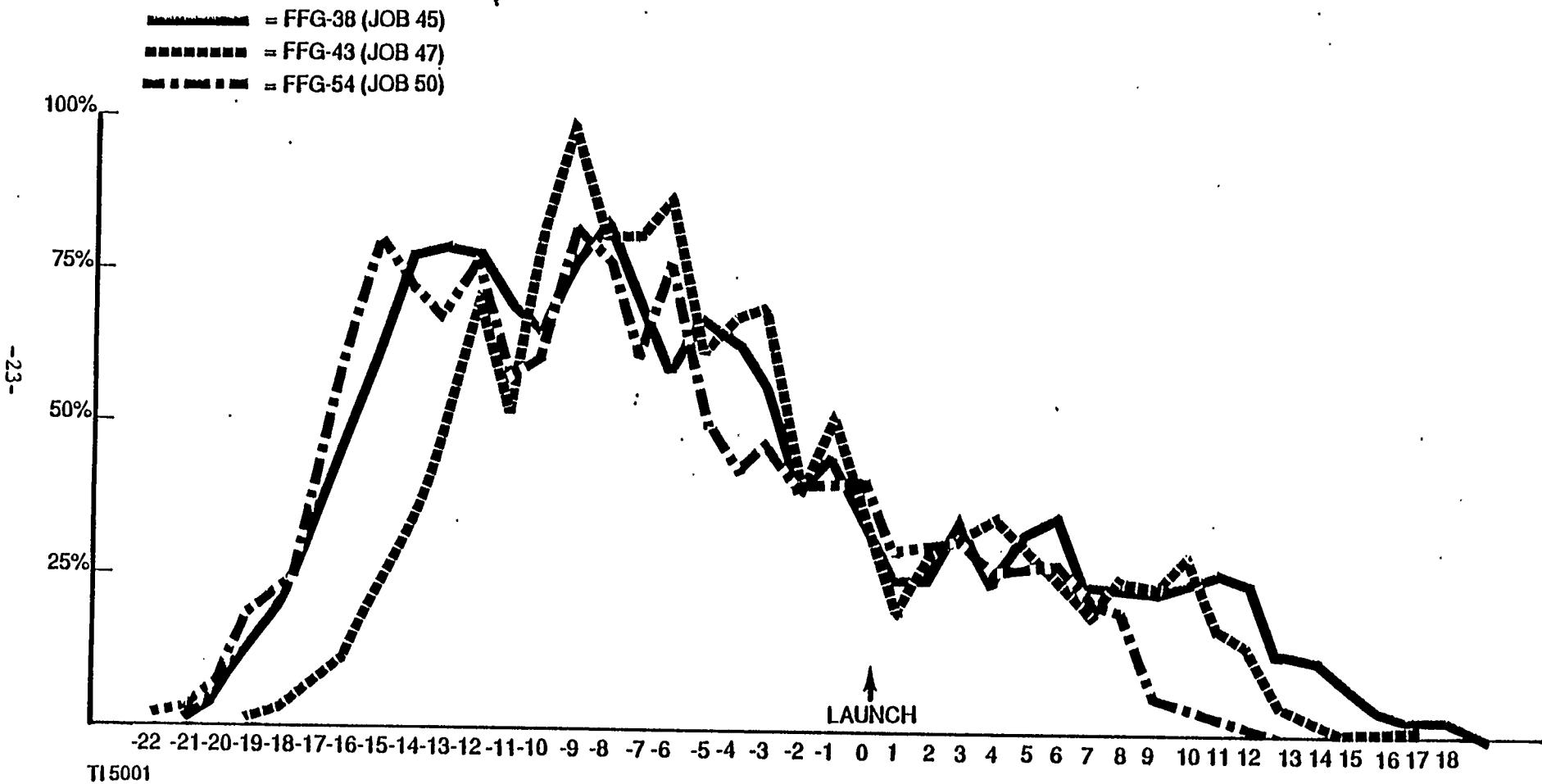
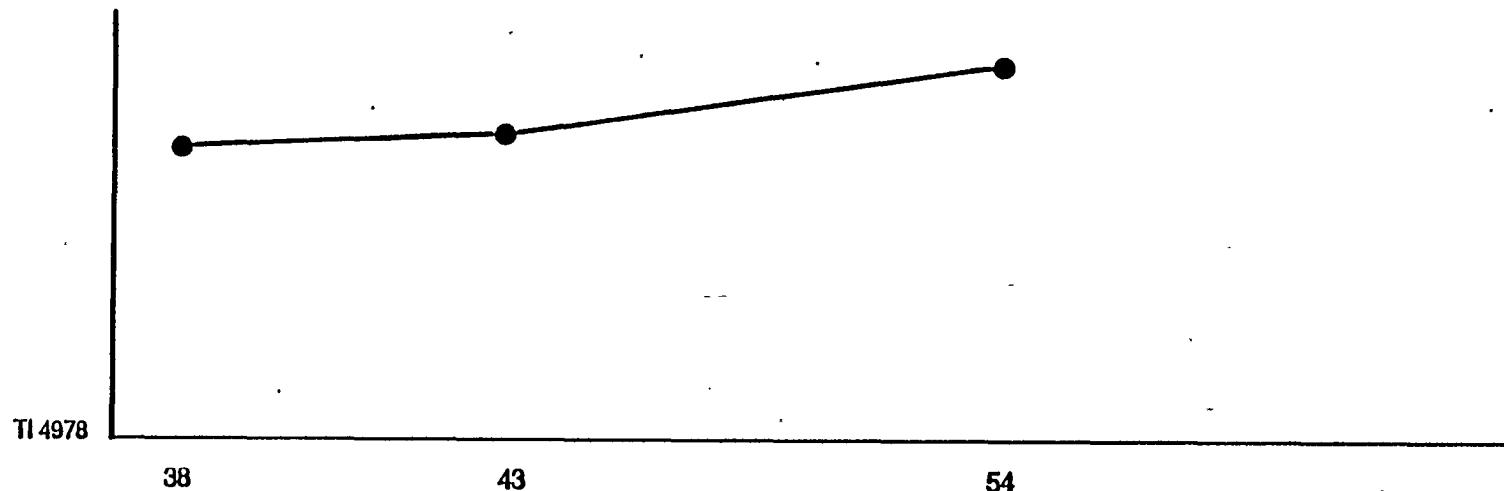
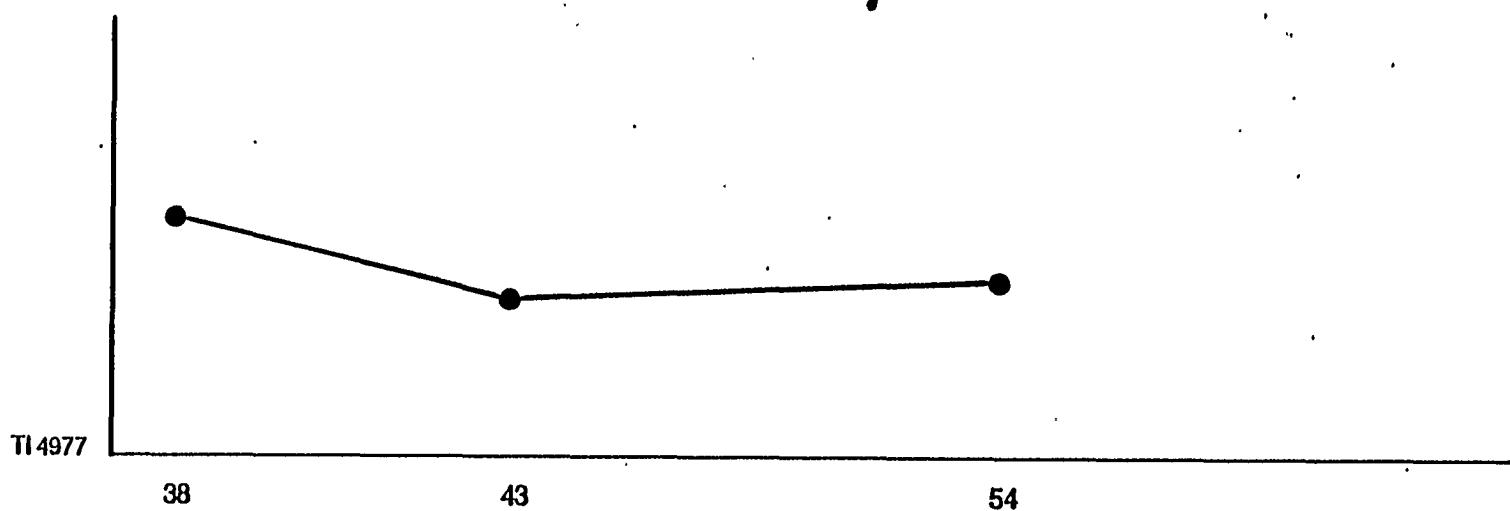


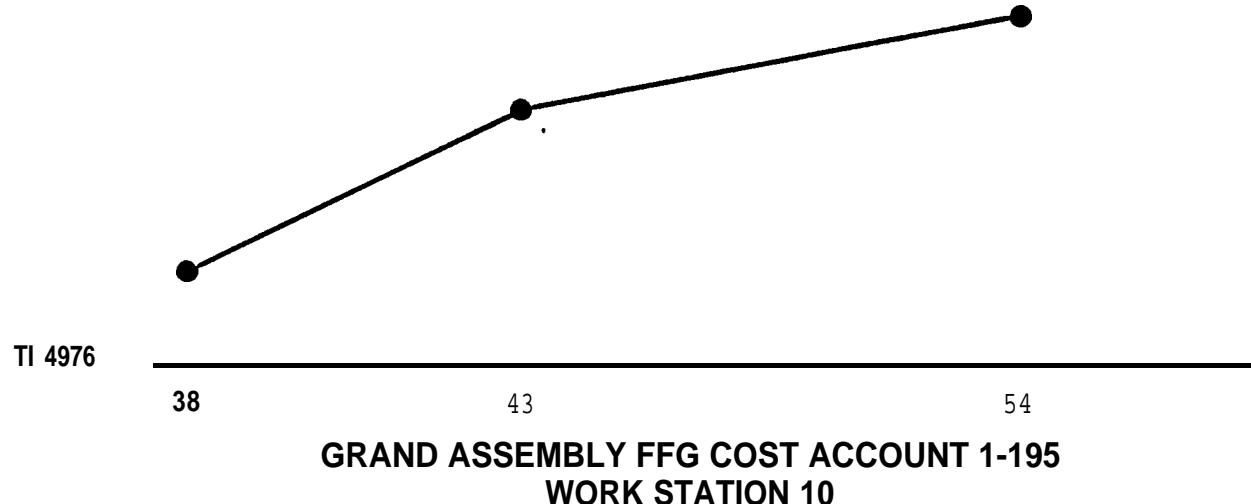
FIGURE 2.2.2 DEPT 1 MANNING COMPARISON



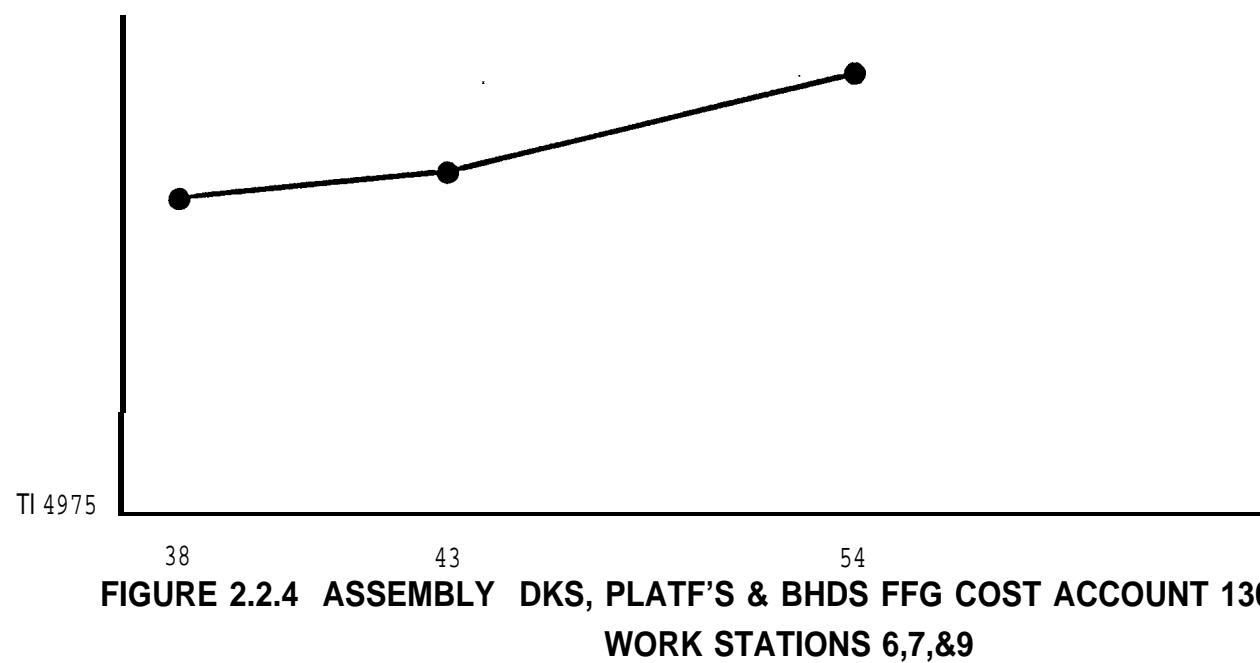
**ASSEMBLY SIDE SHELLS FFG PROGRAM COST ACCOUNT 111
WORK STATIONS 5-6-8**



**FIGURE 2.2.3 PREPARATION FFG COSTS ACCOUNT 110
WORK STATIONS 1,2,3 & 4**



-25-

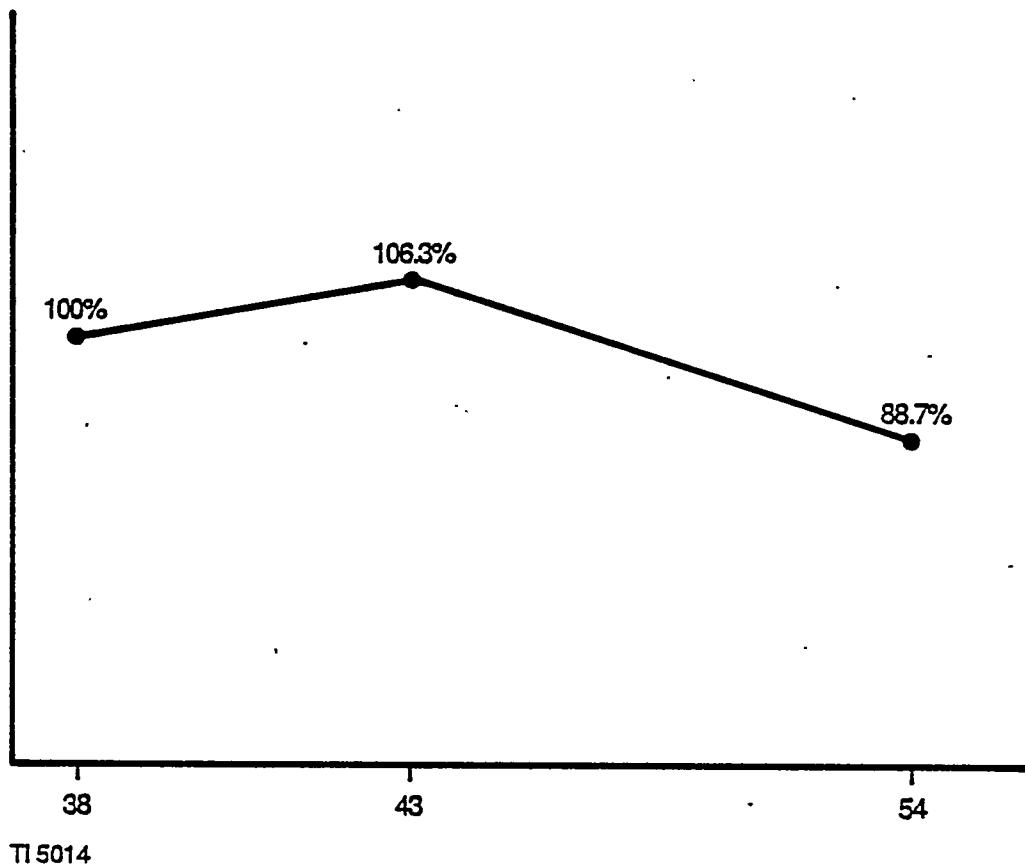


The manhour graphs of the assembly of side shells (cost account 111) and decks, platforms and bulkheads (cost account 130) rise similarly and in accordance with the previous analysis of the inefficiencies resulting from the increased involvement by other outfitting crafts.

The manhour graph of the grand assembly (cost account 1-195), however, portrays to a small degree the essence of the three factors noted as contributing to the increase in costs. Analysis of inspection deficiency reports (IDR's)(3) shows that an increase of 148% in IDR's was experienced for FFG-43. A significant amount of the increase in the need for rework was due to the fact that blocks were overloaded at this stage of construction with the work being done on the ground versus the ways.

Figure 2.2.5 shows the erection manhours (cost account 2-195). An increase for FFG-43 was experienced due to some rework along with delayed grand assembly work caused by the influx of outfitting at that stage. By the time of the construction of FFG-54, work accomplished on the building ways on earlier ships had been completed earlier to support outfitting and thus allowing the erection manhours to decrease nicely.

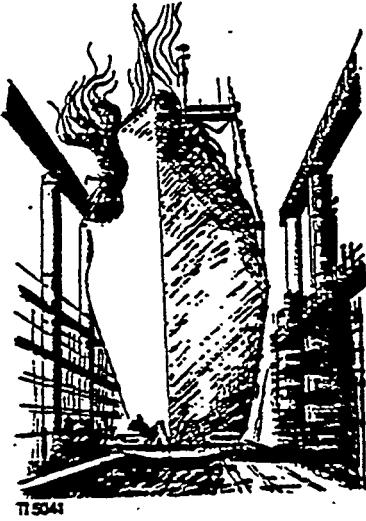
(3) Inspection Deficiency Reports are the means TLA uses to report/record construction discrepancies or the need for rework. The required rework is coded in such a manner that the costs are separately collected.



**FIGURE 2.2.5 ERECTION FFG PROGRAM COST ACCOUNT 2-195
WORK STATION 11 & 12**

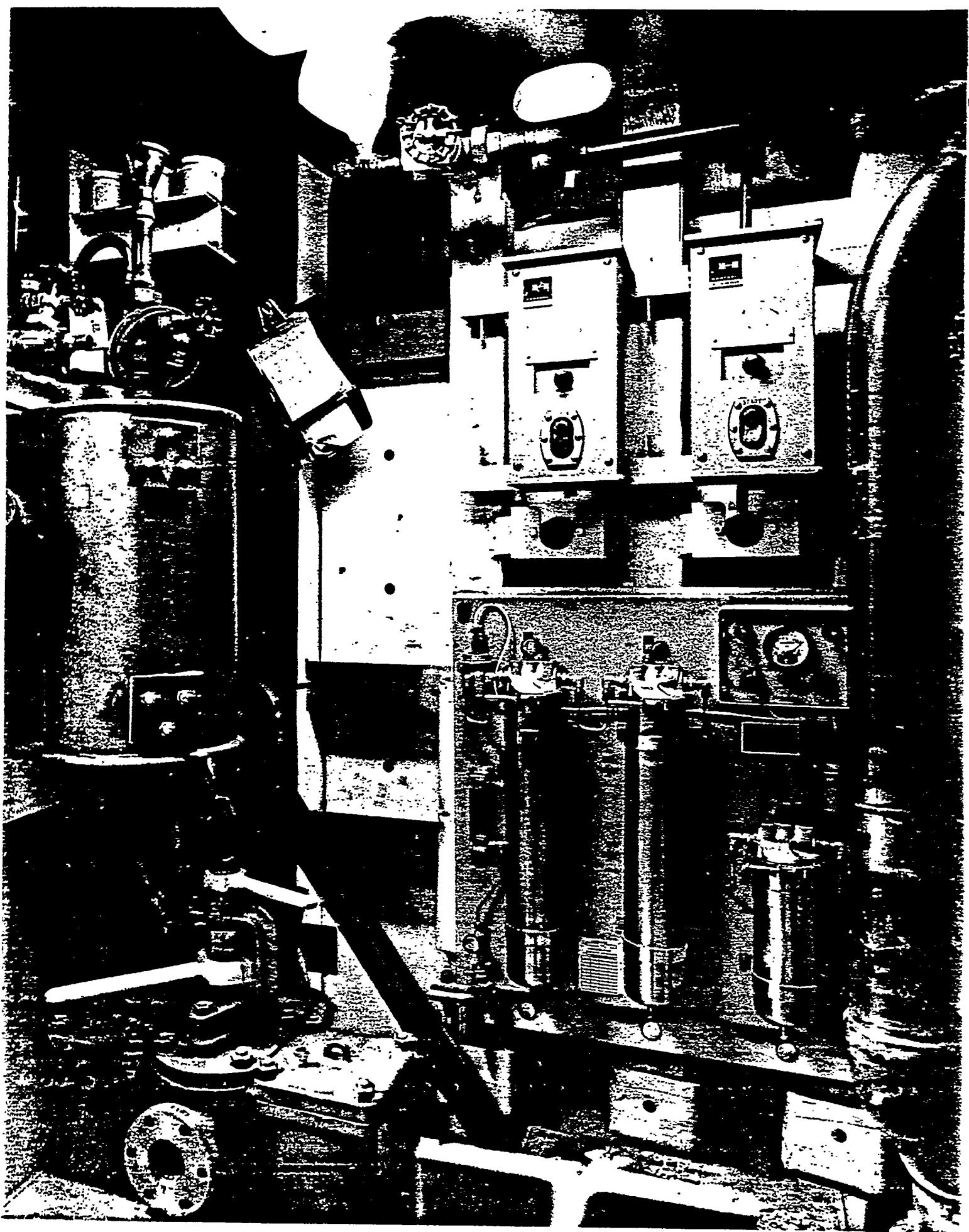
2.3 JOINER/ SHIPWRIGHTS, DEPT. 2

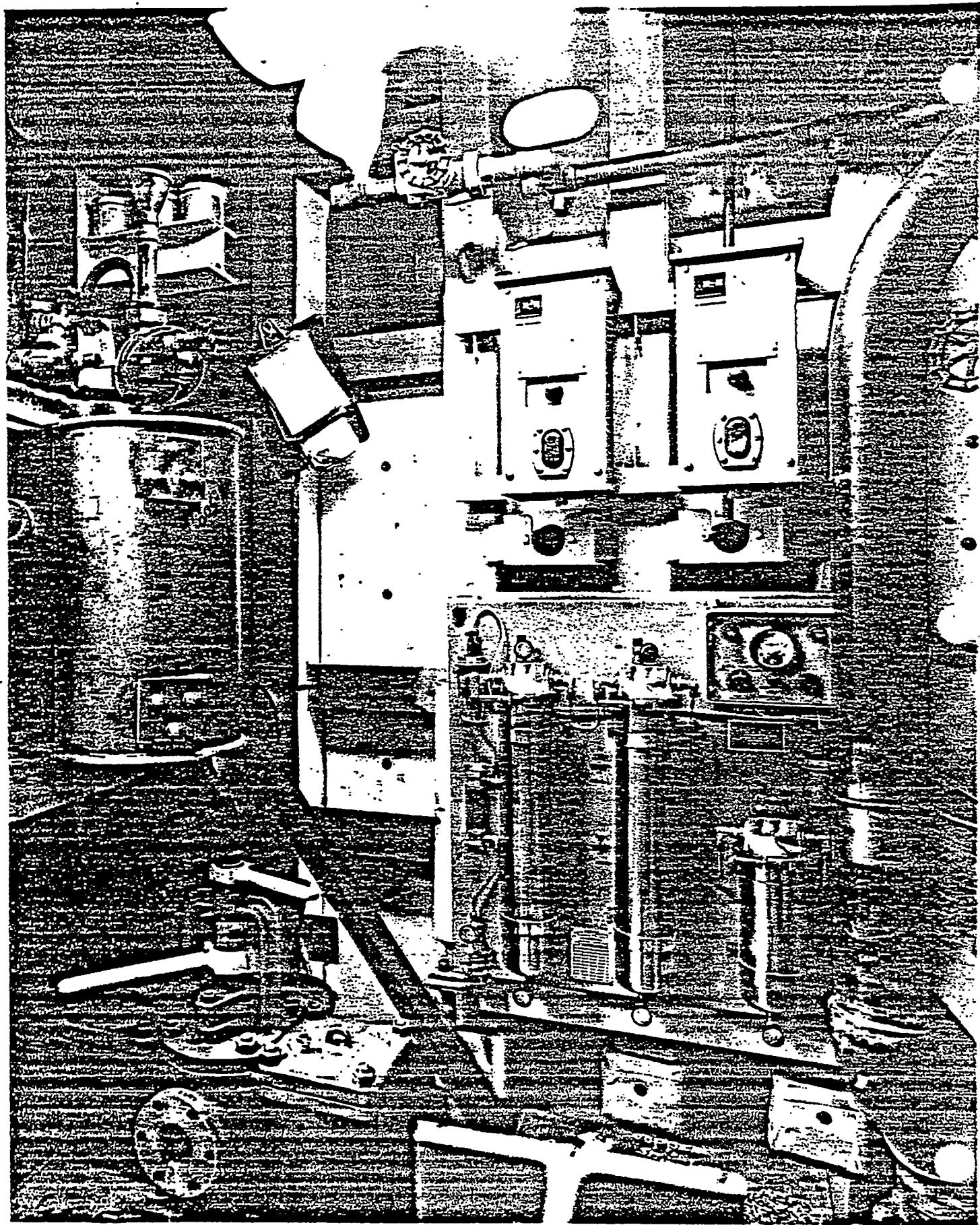
Department 2 is responsible for a variety of tasks such as carpentry, ship's alignment, and label plates. A few of these tasks were impacted significantly. These are in the areas of insulation, shoring of the units during erection, and launching.

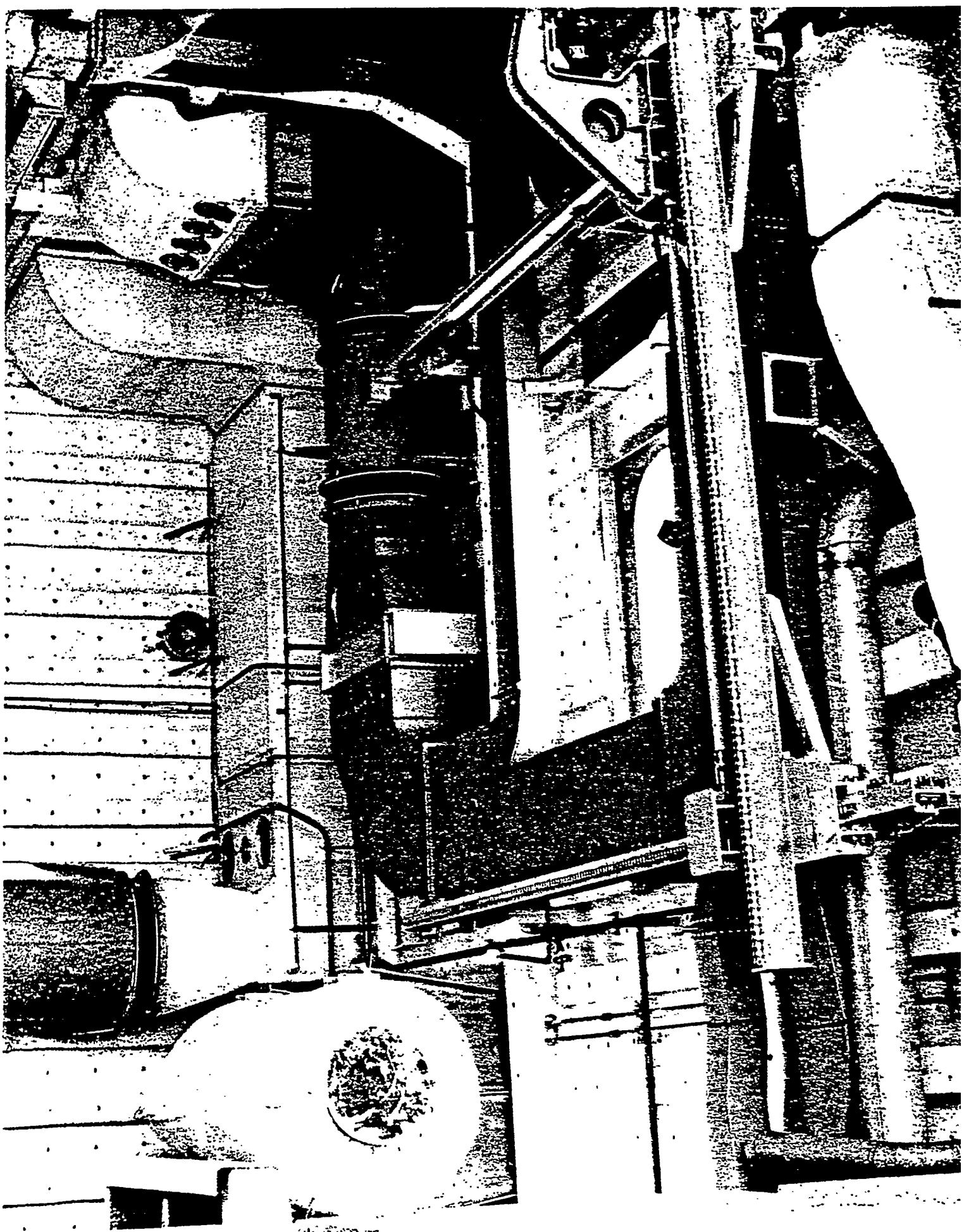


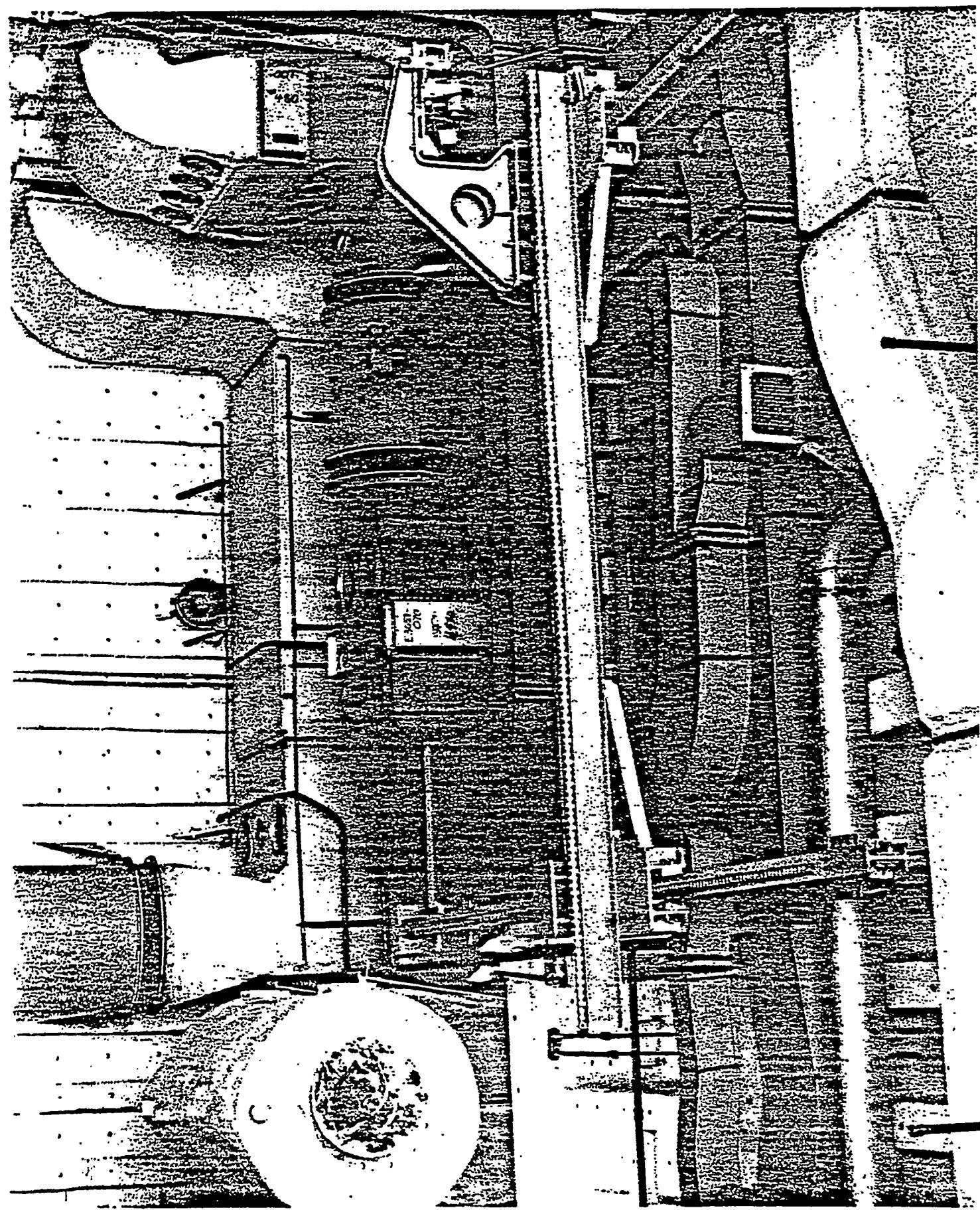
The impact on the shoring requirements for the ship and the launching of the ship is due to the increased weight caused by ZOFM construction. This is described in Section 2.11 which addresses the Engineering (Department 70) problems. Engineering had the responsibility of reviewing the adequacy of the shoring and the launching cradle design at the time of implementation of ZOFM, but Department 2 was responsible for the work itself.

The largest number of manhours are used by Department 2 for installing insulation (cost group 600). Department 2 incurred a high degree of rip-out and rework of insulation as a result of too early installation. This rip-out and rework was charged to the craft requiring that rip-out. This contributed to a large apparent savings in the installation of insulation.









The fact that insulation was installed earlier than the equipment and systems normally in the way also contributed to the savings. The insulation was thus installed with a reduced difficulty factor. Figures 2.3.1 and 2.3.2 show this apparent cost saving for FFG-43, while the other crafts show increases.

A more realistic cost is shown for FFG-54 where a balance was reached on how much insulation should be installed at the time of on block outfitting. A saving greater than TLA's required learning tune was still realized.

Figure 2.3.3 is a good representation of how ZOFM construction supports the earlier delivery of a ship. The solid line shows the normal Department 2 manning on a ship that is built according to traditional construction methods, with a high manning peak near the end of the contract. The figures for FFG-43 show the start of leveled manning, and FFG-54 even more so. Each ship's manning peaks toward the end, due to jobs that finish after the completion of outfitting (such as label. plates). Nevertheless, more work is completed prior to launch and the ship is completed earlier.

Learning where and when to install insulation was one of the major lessons learned by Department 2 as a result of changing from system oriented construction to ZOFM. In the initial phase too much insulation was installed at the earlier stages of on block outfitting. The first illustrations show FIG-54 (note the H-500 on the tank depicting Job 50 or FFG-54) with insulation only where necessary for the difficult areas. The second illustration shows FFG-43 (note the H-470 on the vent heater depicting Job 47 or FFG-43) with full insulation that had to be ripped out later for other outfitting items.

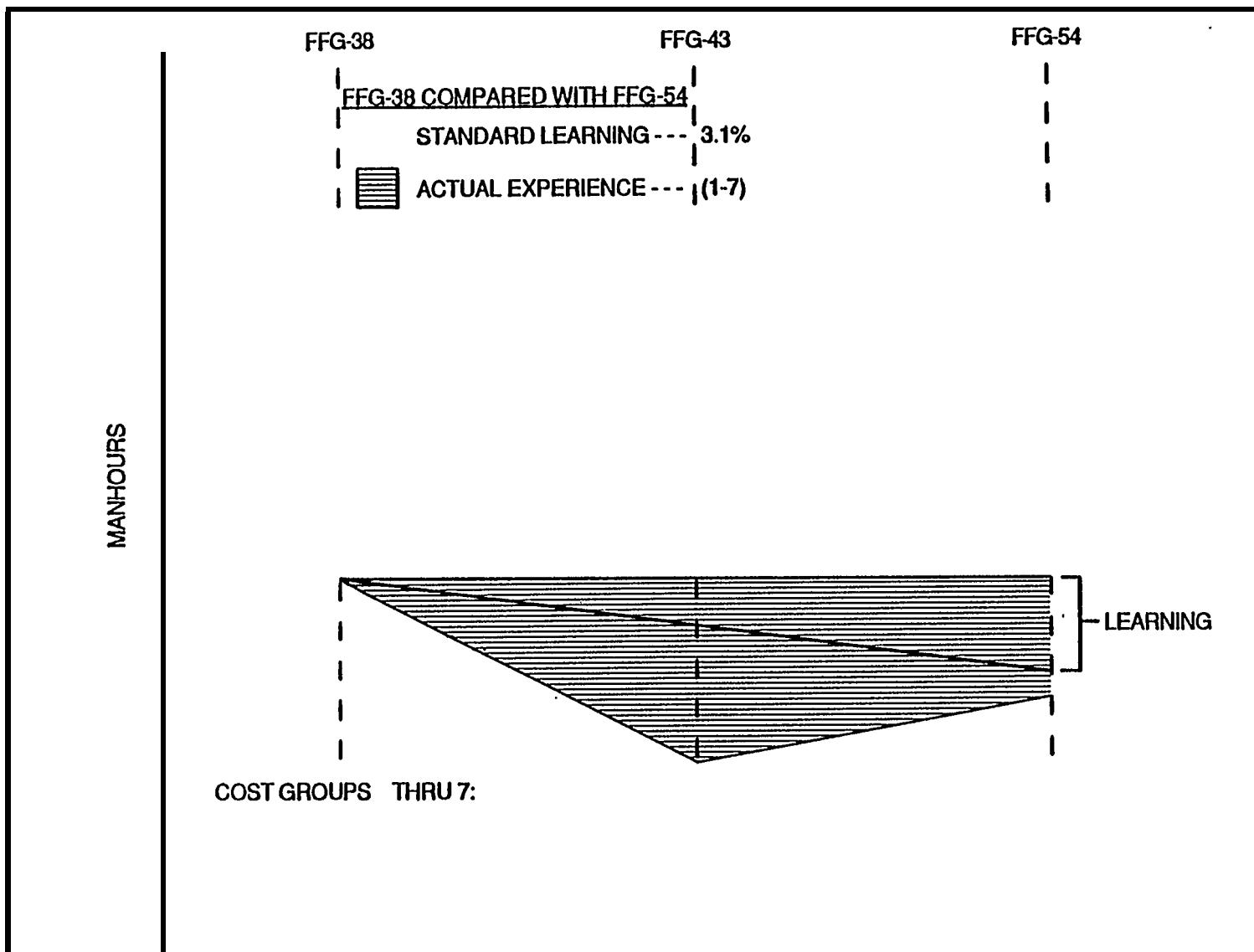


FIGURE 2.3.1 CRAFT 2 - JOINER - SHIPWRIGHTS

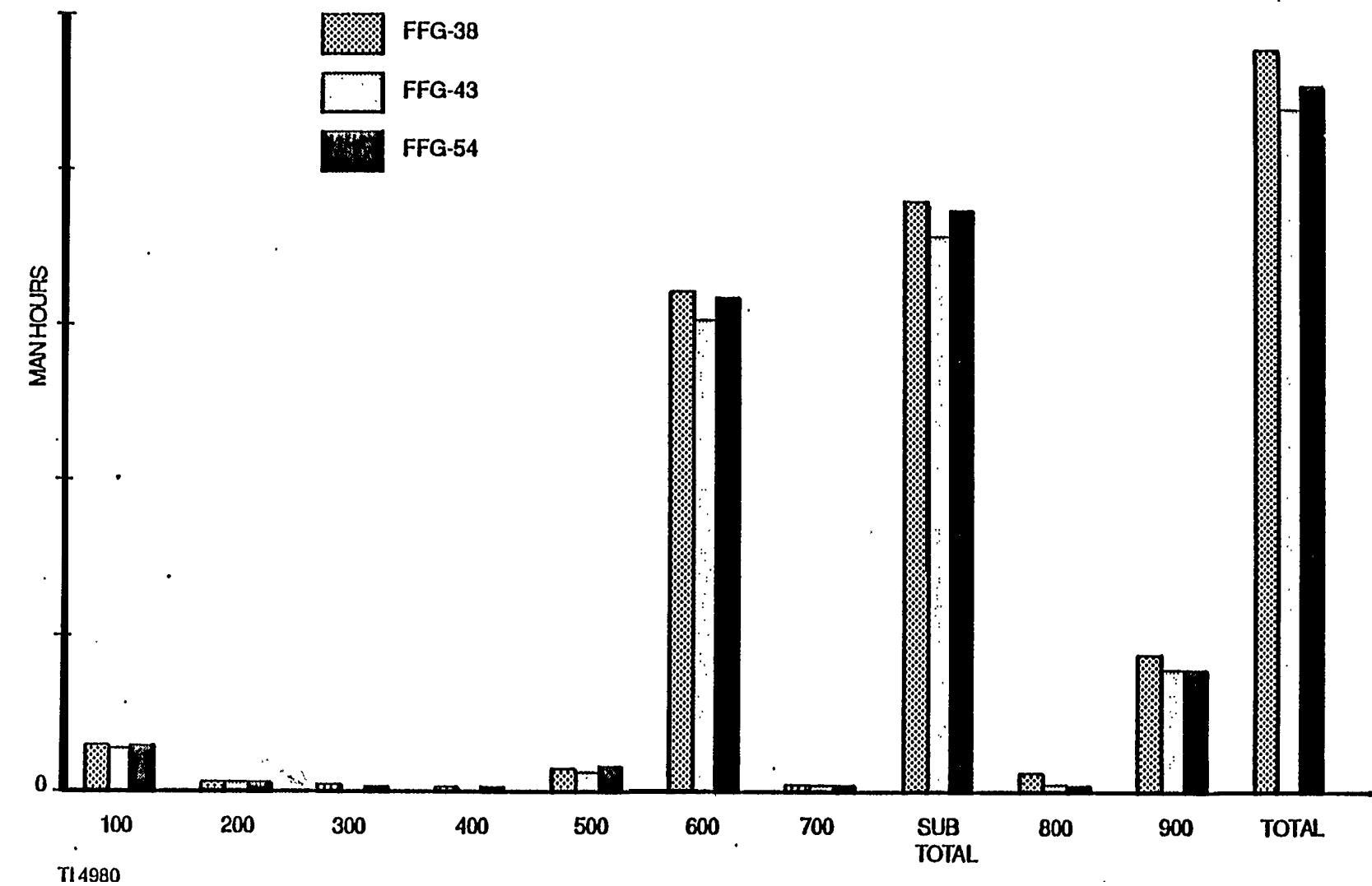


FIGURE 2.3.2 DEPARTMENT 02

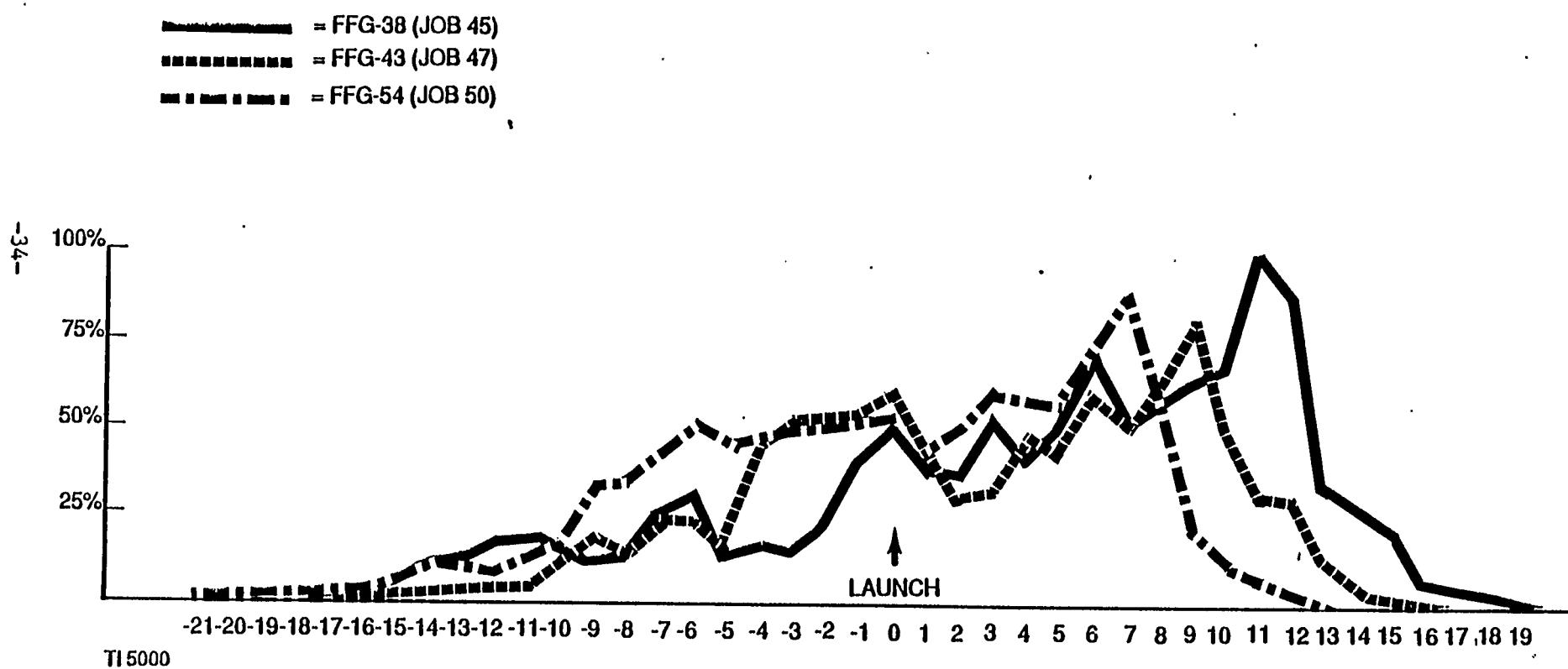


FIGURE 2.3.3 DEPT 2 MANNING COMPARISON

.4 SHEETMETAL/DEPT. 3

The major effort for Department 3 lies in cost groups 500 and 600, as shown on Figure 2.4.1. The installation of heating, ventilation and air conditioning systems (HVAC) falls in cost group 500, and metal joiner bulkheads, cabinets, shelves in cost group 600.

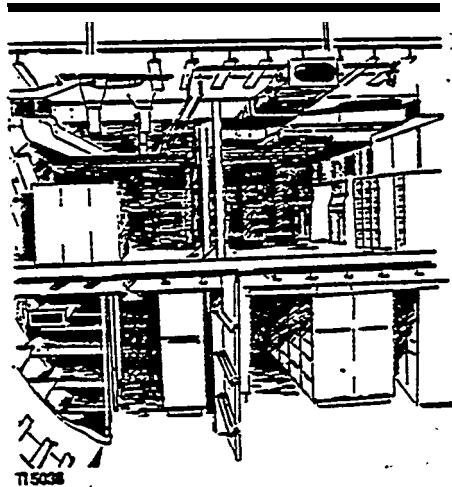


Figure 2.4.1 shows an increase in manhours for EFG-43. the focal point of the transition. Manhour expenditures in cost group 600 were responsible for this increase. Difficulties in acquiring cabinets and other vendor items earlier than originally scheduled dates was part of the problem. This caused extra manhours to be spent for various reasons including: the need to reassign manpower to uncompleted areas while awaiting material: the extra hours spent working-around those missing items or fabricating these items in house if it was critical; the too early installation of metal joiner bulkheads in the way of other outfitting items, resulting in the rip-out of these bulkheads.

The real gain in construction efficiencies for Department 3 was in the area of HVAC. The initial returns showed a significant savings for the fabrication and installation of HVAC systems. This was due to the easier

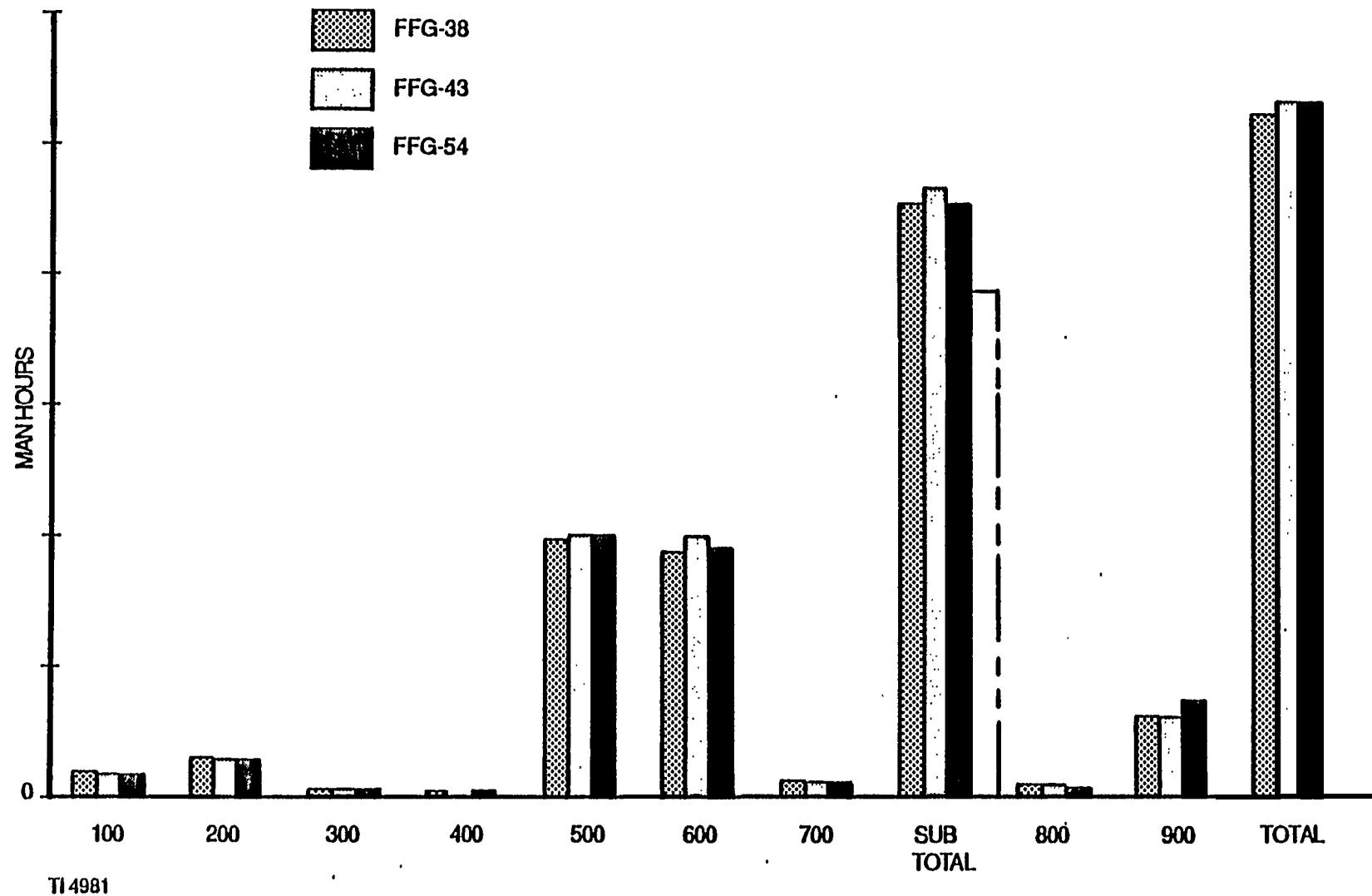


FIGURE 2.4.1 DEPARTMENT 03

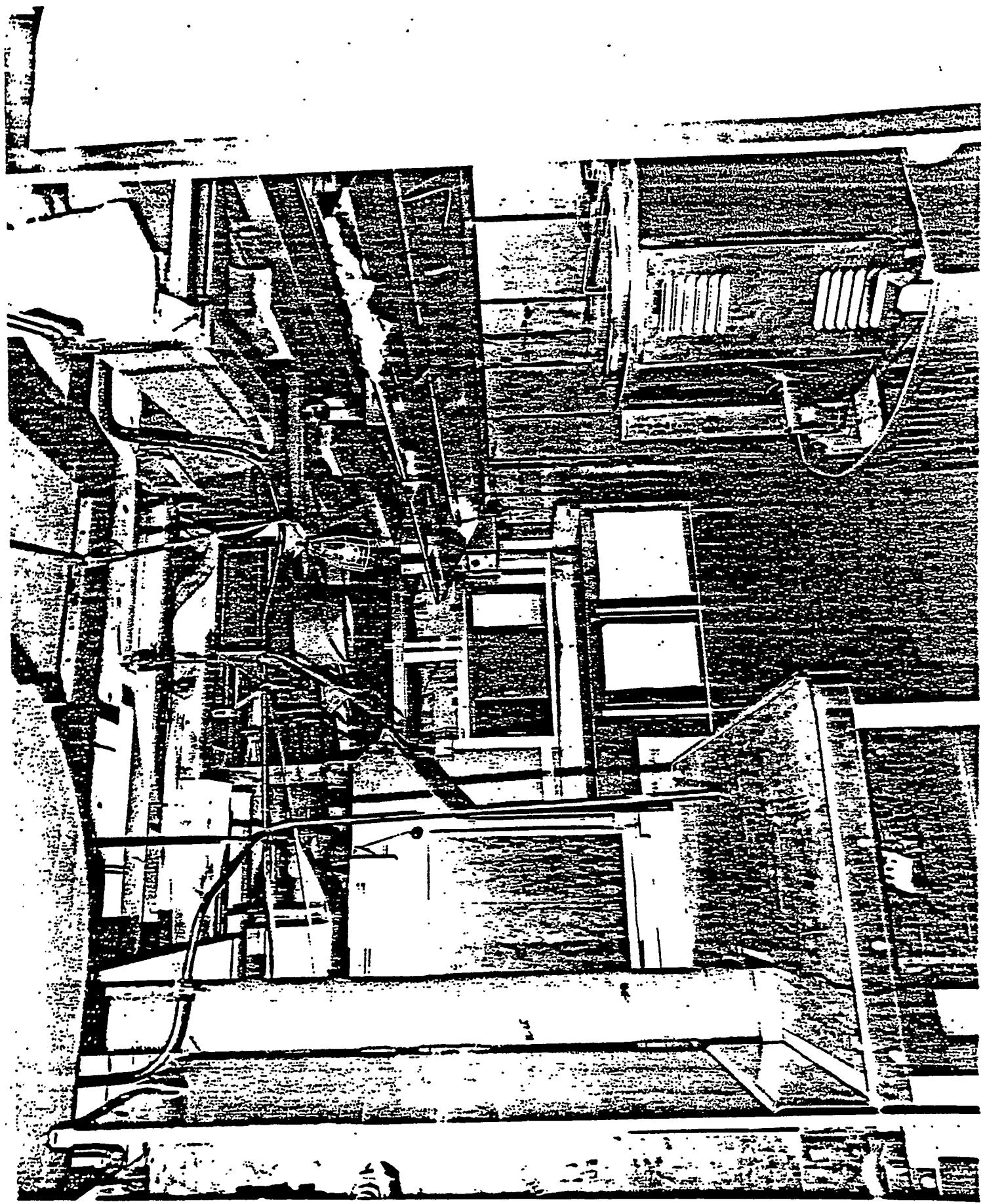
access afforded on the platens and the use of down hand welding during installation. The problem was that the ducting must be installed after: 1) piping, 2) insulation. and 3) cables. The plaudits for the quick response to the decision for ZOFM construction were erased when the fully riveted, gasketed ducts had to be removed in way of the other outfitting. An example of this is shown in the following picture.

After the initial sting of a too early installation on the first few blocks, the pendulum swung a little too far in the opposite direction. Ventilation installation was withheld until after other outfitting was completed. As mentioned in section 2.3, the insulation was installed without the ducting being installed. This resulted in the insulation being ripped out in way of the ducting hangers, and the cost of this rip-out absorbed by the ducting budget. So, the savings gained by the benefits of ZOFM construction were balanced by the losses due to TLA's inexperience.

By the time FFG-54 was being constructed, most of the problems experienced earlier in cost group 600 were corrected. However, the construction of FFG-54 did provide a unique problem adding to the complexity of this study, caused by the lower capacity of the crane on Ways #2. TLA can only lift 82% of the weight on Ways #2 as compared to that on Ways #1.

This meant that joiner equipment, cabinets and shelves had to be installed after block erection. Therefore, cost savings realized for FFG-54 were offset as shown on Figure 2.4.1.

Results of FFG-57, the ship following FFG-54, were completed too late to be included in this report, but preliminary results indicate that TLA experienced significant savings in Department 3. FFG-57's subtotal of the



manhours for cost groups 100-700 is shown by the phantom line on the 100-700 cost group subtotal on Figure 2.4.1. TLAA also gained valuable experience in identifying which HVAC components can be installed and which were to be only temporarily installed to provide easy access for other outfitting requirements as shown on the following illustration.

The overall manpower costs for each ship in this study were approximately the same for Department 3. The redistribution of the manpower however resulted in a shorter time span from launch to delivery as well as contributing to the overall shorter construction period for the ship as shown in Figure 2.4.2.

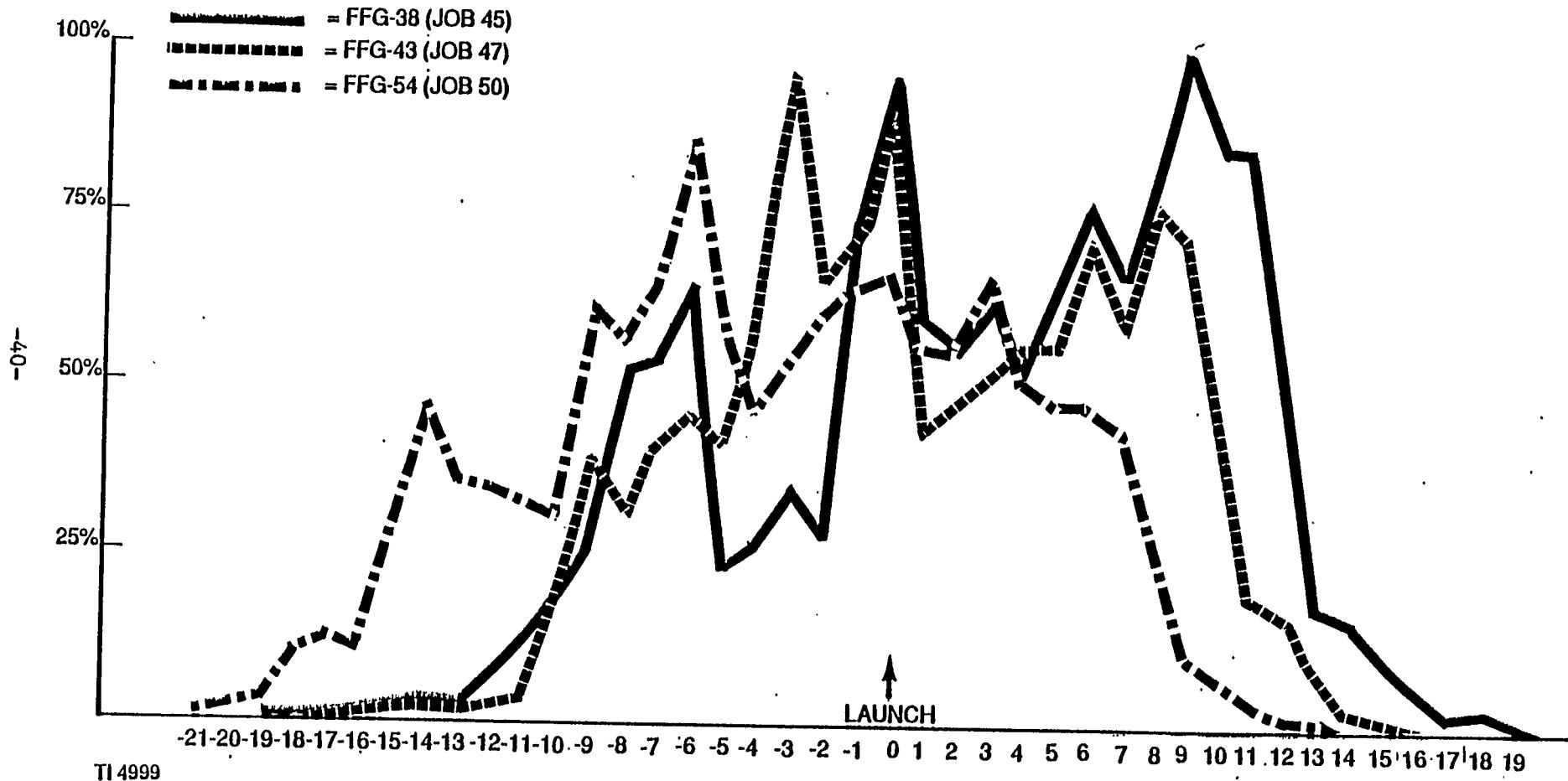


FIGURE 2.4.2 DEPT 3 MANNING COMPARISON

2.5 MARINE MACHINISTS/DEPT. 6

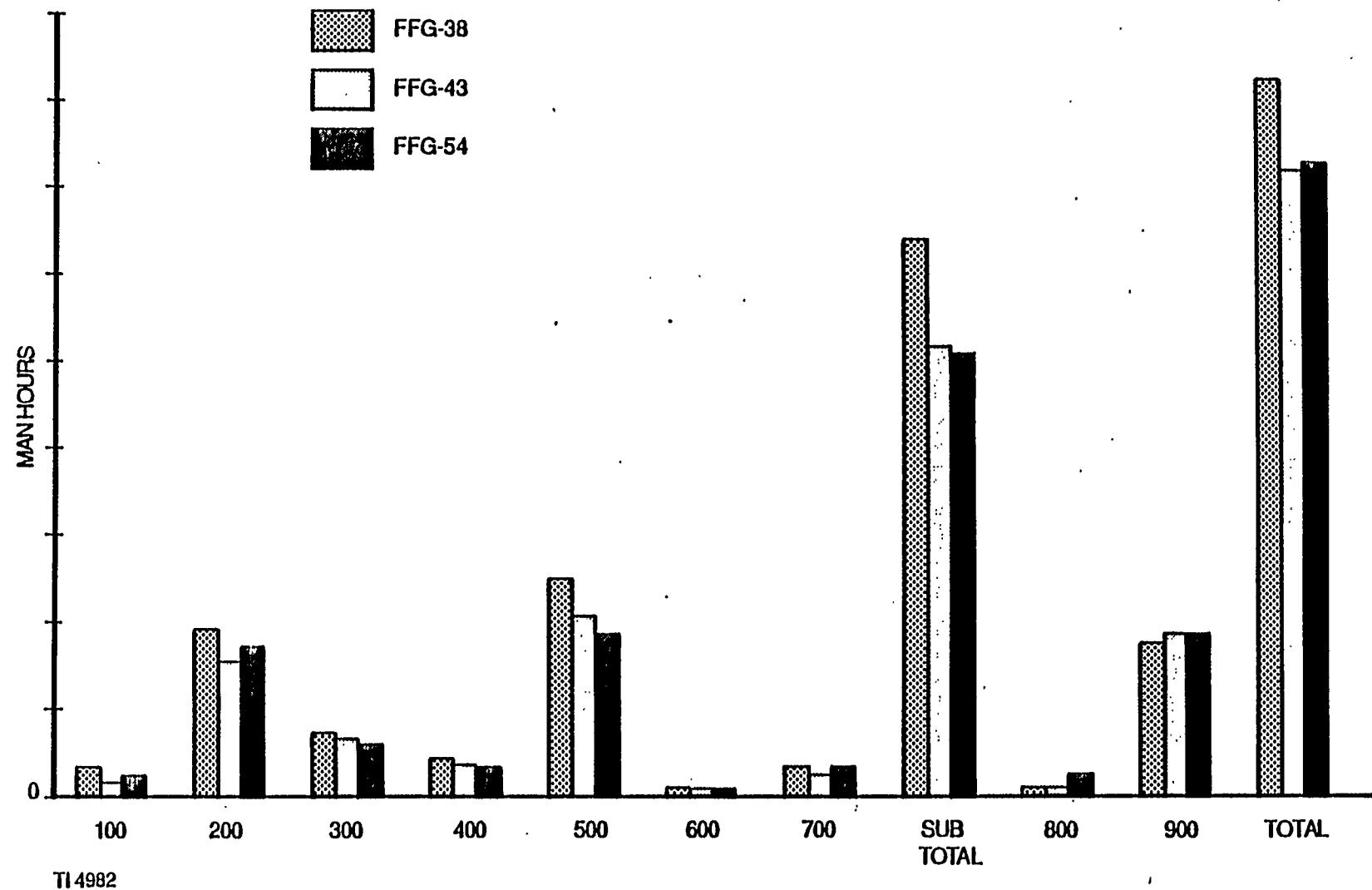
Department 6 is responsible for installation and alignment of all the equipment (over 50 pounds) in addition to the obvious responsibilities of machining tasks outside of the machine shop.

As can be seen on Figure 2.5.1, Department 6 experienced a significant drop in the number of manhours as soon as ZOFM was implemented on FFG-43. Figure 2.5.2 provideg an enlarged view of this change in manhours to show that the advantages of ZOFM were recognised immediately by Department 6, and then the techniques were refined for smaller but improved productivity.

The main factor in the cost savings is that the equipment was loaded while in what is called a blue sky condition in the shipbuilding industry. That is, the working area has no cover over it and is open to the sky. (TLA likes the term because of our cooperative weather conditions.) Prior to ZOFM construction. TLA required a high degree of-assistance from the rigging department in order to manhandle equipment to its below deck location. The first of the following illustrations is an optimum example of equipment loaded at blue sky condition.

Some blocks are constructed in such a way that the full blue sky condition is not possible. TLA then loads this equipment from the open end of the block. TLA is able to still utilize the crane for loading, while needing only a limited amount of rigging assistance. The second of the following illustrations is an example of the next level of optimum loading conditions.

Still another advantage of loading equipment on block is the fact that piping and electrical. connections can also be made at the on-block stage of construction. The accessibility is much better at this point, and the



TI 4982

FIGURE 2.5.1 DEPARTMENT 06

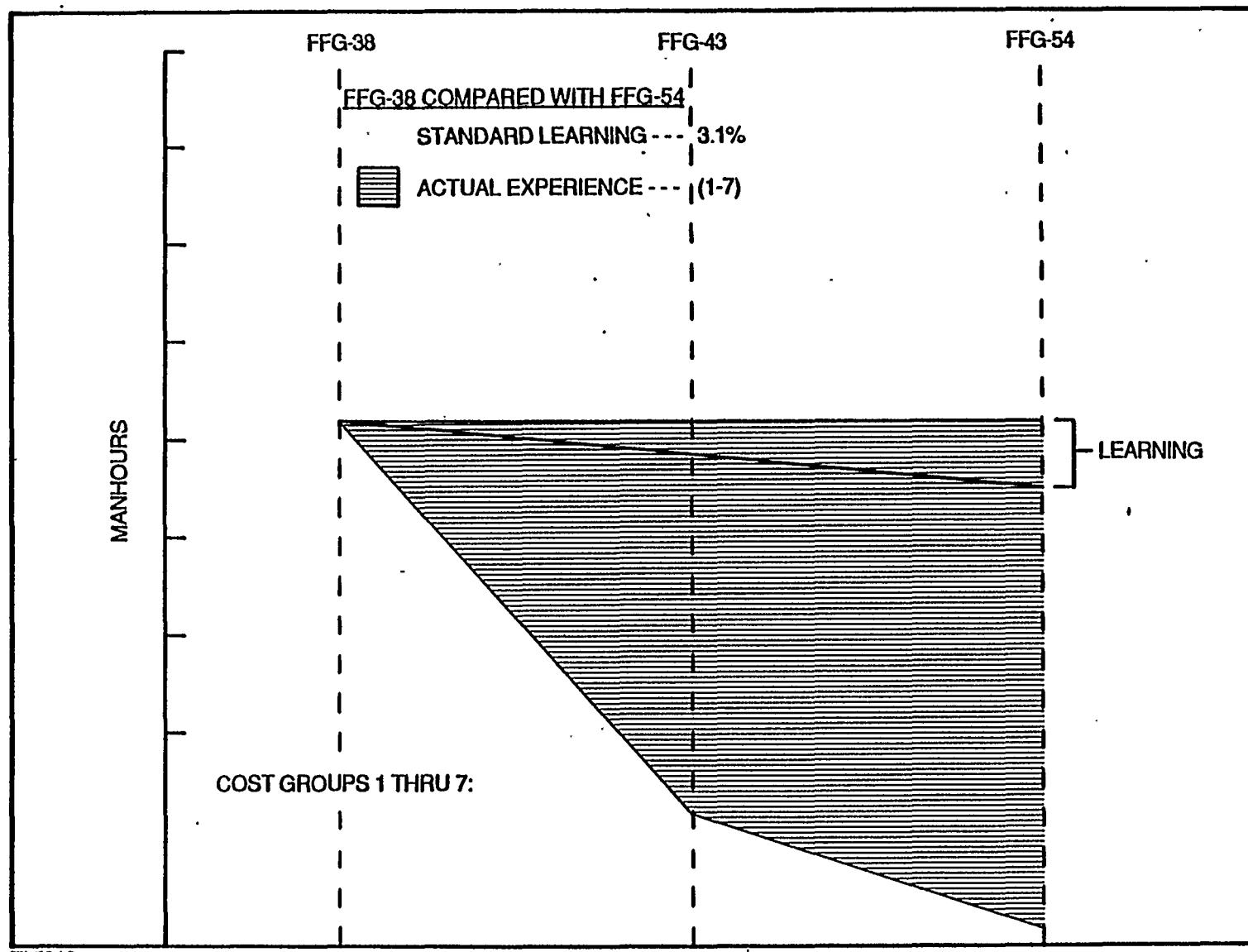


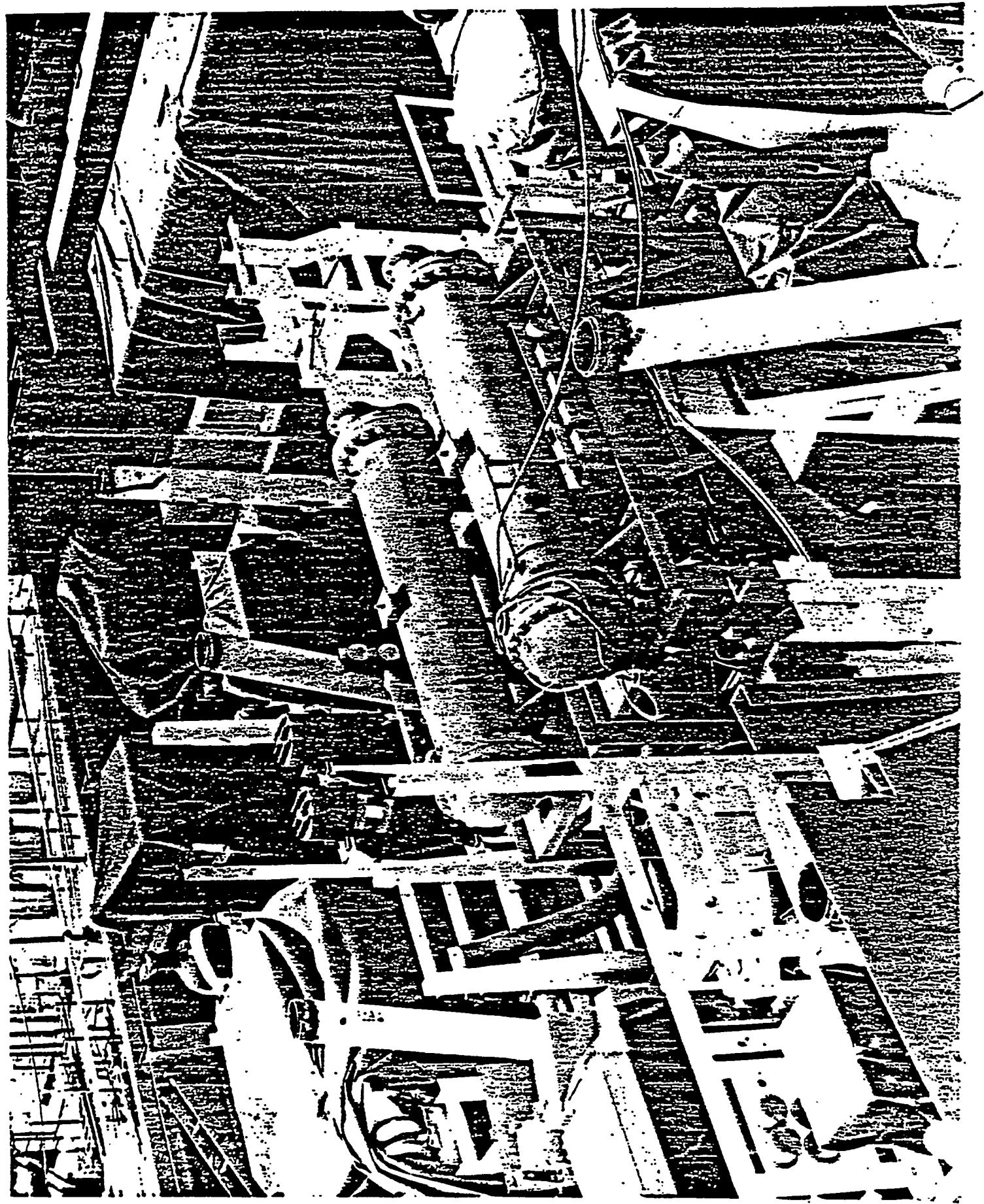
FIGURE 2.5.2 CRAFT 6 - MARINE MACHINISTS

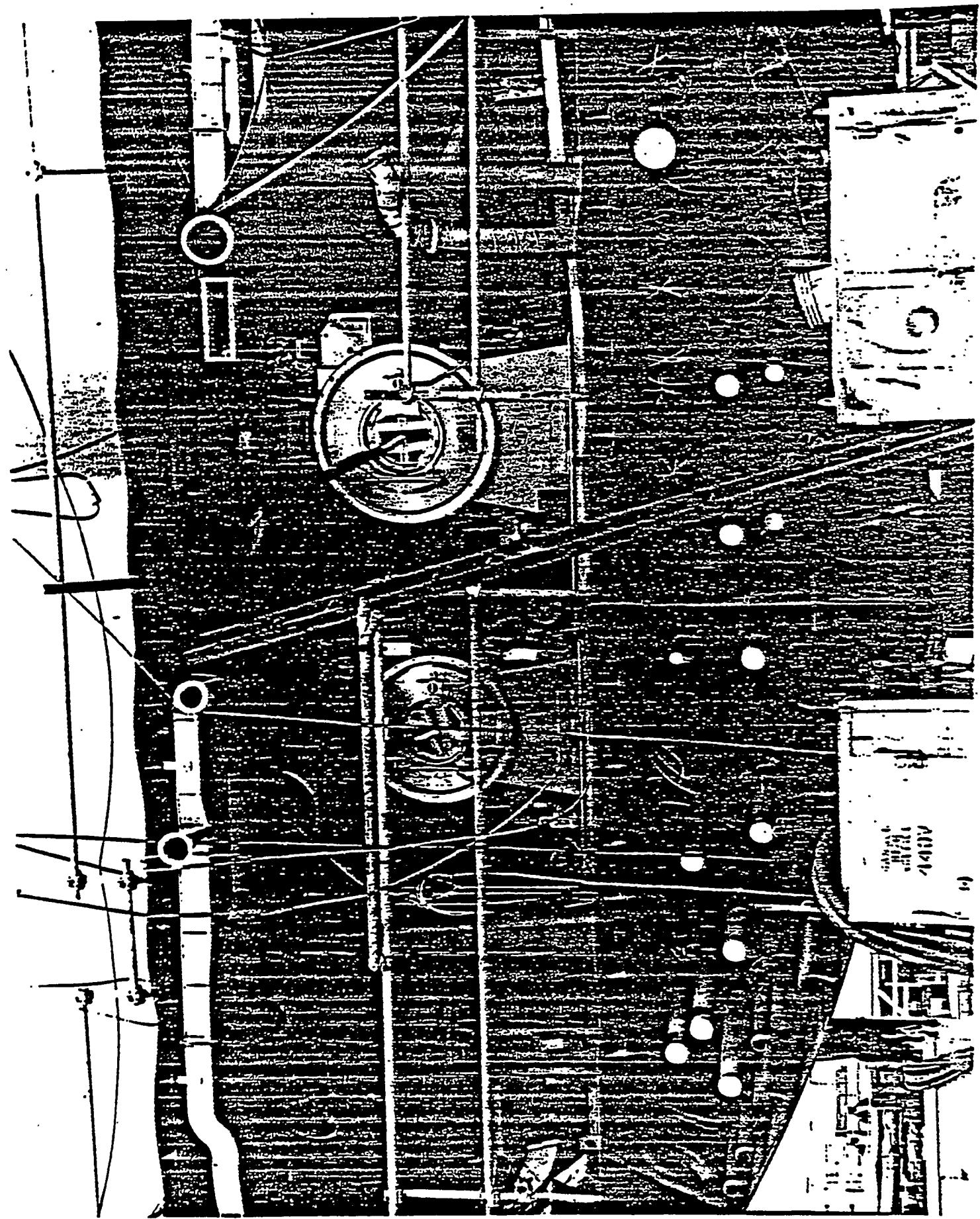
times required both to reach the installation and hook up the system much reduced. The third of the following illustrations shows this.

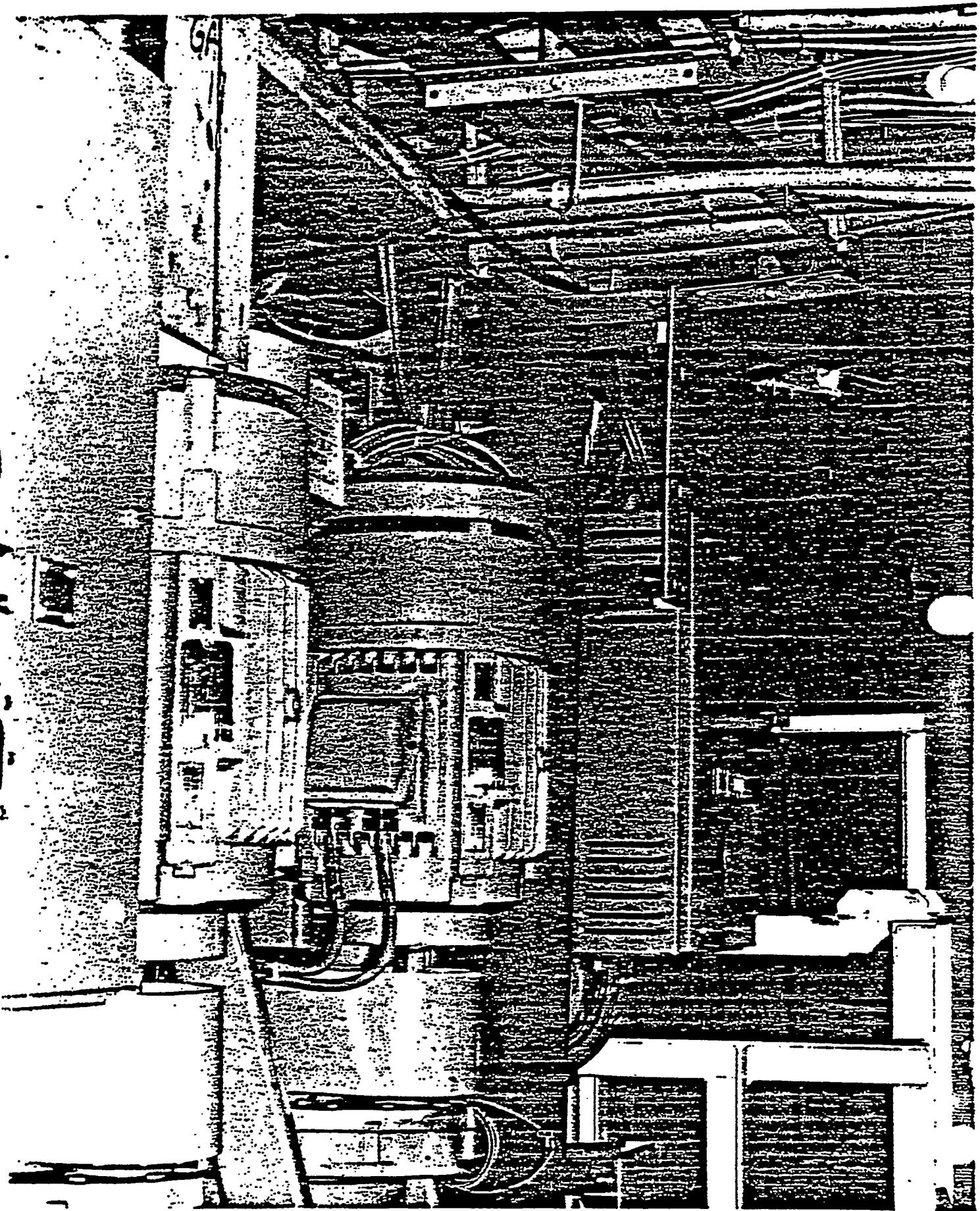
Not all the equipment could be brought in to suit the earlier need dates required to support ZOFM. The cost savings experienced by the available equipment being installed on block made it all worthwhile-as the figures show. The additional costs incurred for loading the late arriving equipment after block erection are attributable to the following factors:

- 1) Slower rigging due to care taken when rigging through advanced outfitted areas.
- 2) The removal of some interferences caused by advanced outfitting..
- 3) The disassembly of some equipment, when feasible, to fit through existing accesses. This is because the cutting of shipping access holes became undesirable because the advanced outfitting had closed off some of the access routes.

Peak manning of Department 6 did not change drastically, as illustrated on Figure 2.5.3. However, the data does indicate a slightly higher manning prior to launch by the time FFG-54 was constructed, and an earlier cutback on manning in the period after the launch. Department 6 ZOFM effort certainly contributed to a shorter period between launch and delivery.







— = FFG-38 (JOB 45)
- - - = FFG-43 (JOB 47)
- - - - = FFG-54 (JOB 50)

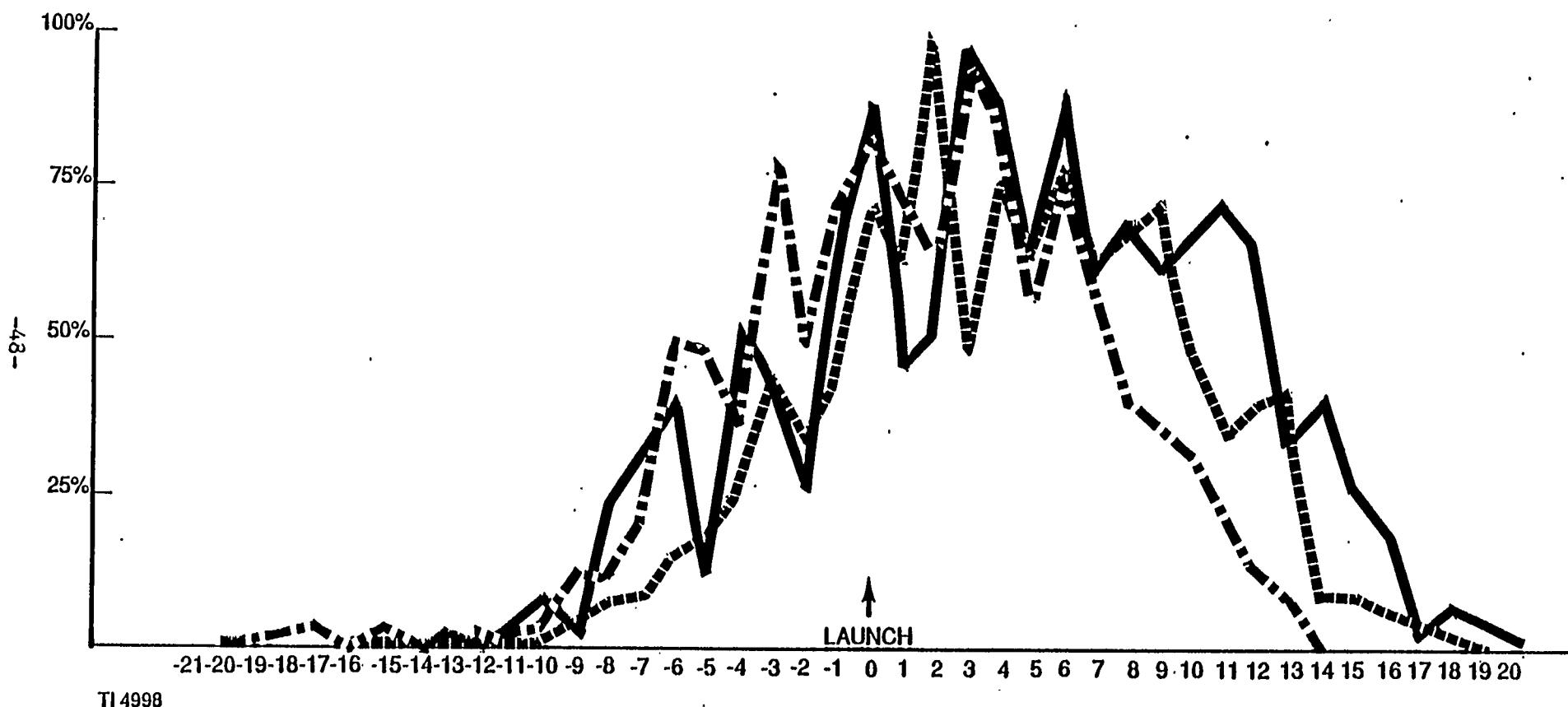
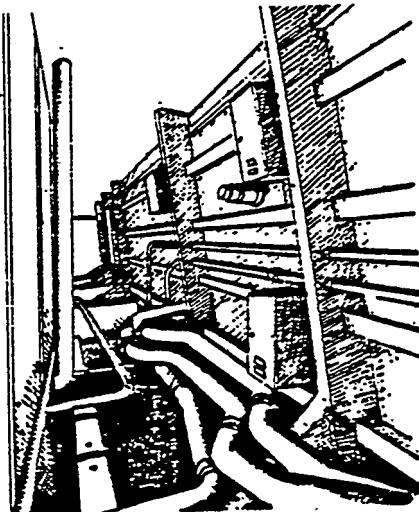


FIGURE 2.5.3 DEPT 6 MANNING COMPARISON

2.6 PIPEFITTERS/COPPERSMITHS, DEPT. 8

Department 8 experienced the highest increase in productivity although Department 6 also experienced a high degree of cost savings due significantly to the decrease in rigger assistance.



Figures 2.6.1 and 2.6.2 show that there was a marked reduction in man-hours. When analyzing the functions of Department 8, one realizes that this reduction was due more to an increase in efficiency within the department than with a reduction of services from other crafts. The reasons for this are:

- 1) Access was easier, as was true for all crafts.
- 2) Requirements for rigging service were also reduced.
- 3) The major difference was the opportunity to fabricate large sections of piping systems prior to installation on the blocks. This opportunity is accredited to the blue sky conditions described earlier.
- 4) Working in the open blocks provided better working conditions that allowed personnel easy access to the work surfaces as opposed to

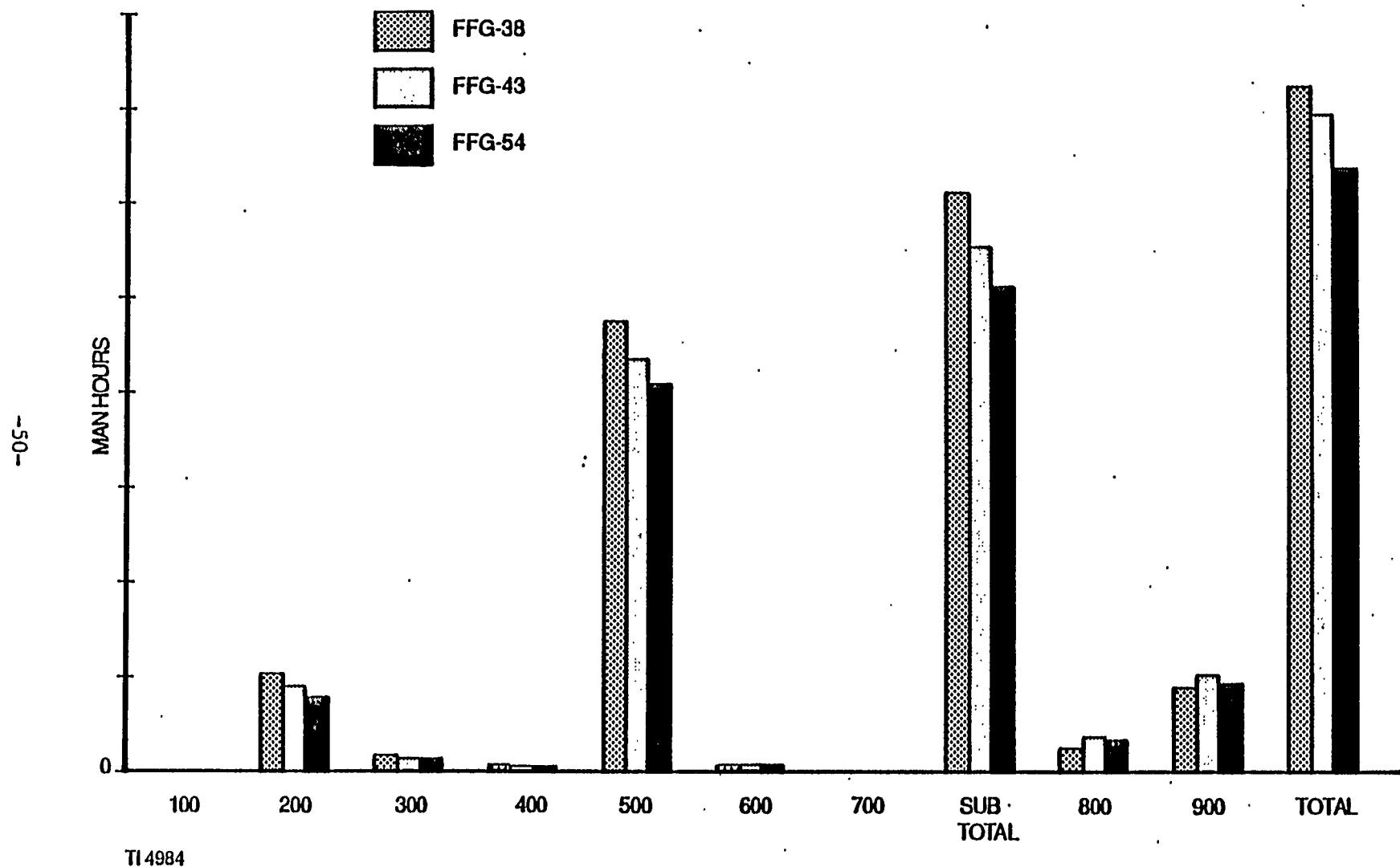


FIGURE 2.6.1 DEPARTMENT 08

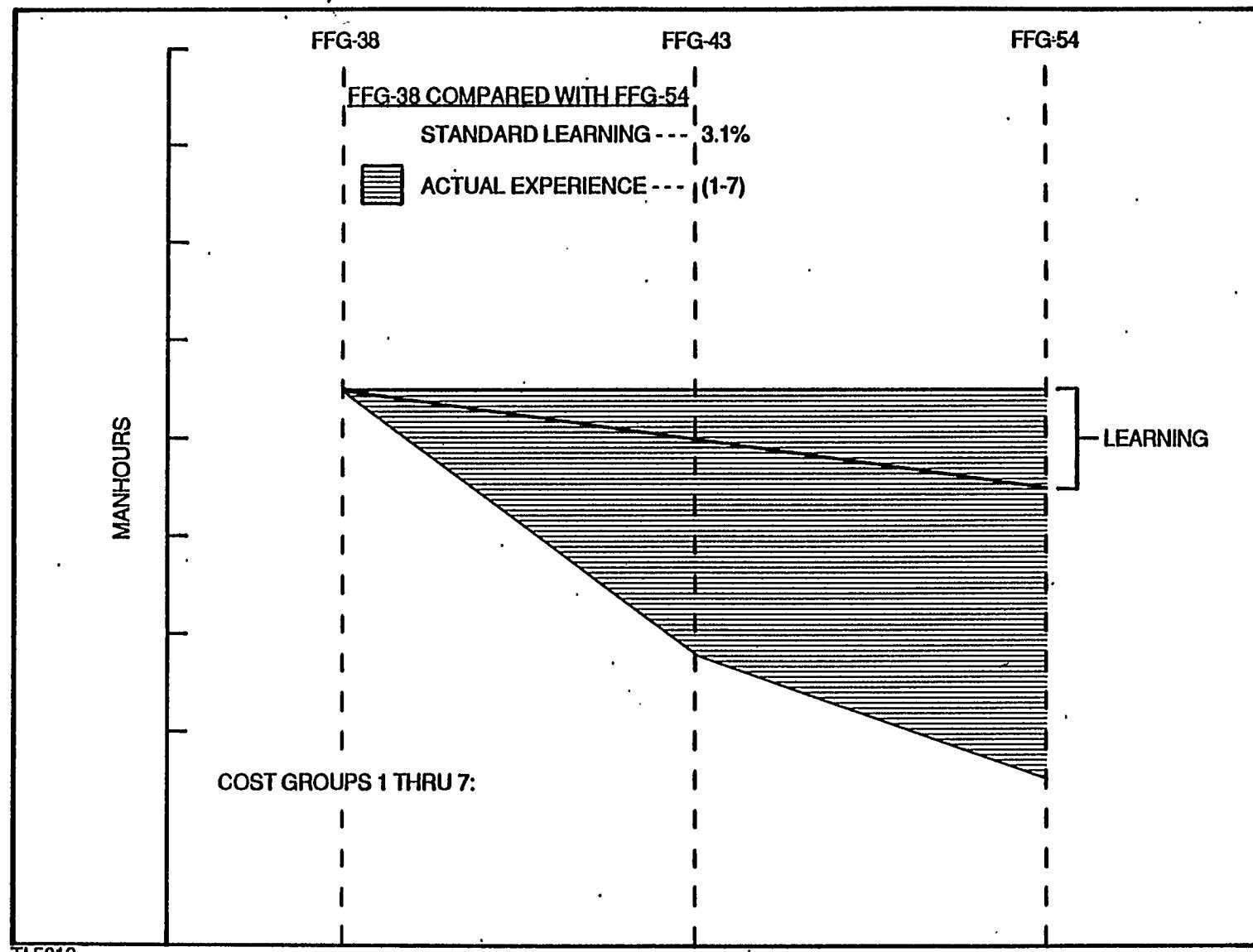


FIGURE 2.6.2 CRAFT 8 - PIPE & COPPER SHOP

TI 5019

trying to accomplish the same tasks in a small congested enclosed area.

Referring back to Figure 2.6.1, it is apparent by the small increase in service costs (groups 800 and 900) that some thought had gone into planning for the above advantages.

The negative aspects associated with Department 8's enthusiastic approach toward ZOFM construction was caused by its taking advantage of the open spaces and starting the installations before Department 1 was ready structurally. This uncoordinated start impacted Department 1 as noted in the section on Shipfitters.

The dramatic change in manning by Department 8 is illustrated on Figure 2.6.3. On FFG-38, little was accomplished prior to launch causing a large peak in manning well after launch. This ship became very congested with personnel jammed in every compartment trying to complete the tasks prior to delivery. This type of congestion in combination with the schedule compression that always occurs between launch and delivery precipitates overtime. The hours charged on overtime are the same hours as straight time when accumulated into the manhour count. The impact is that the cost goes up because of the premium pay for overtime. Figure 2.6.3 also shows that, for FFG-43, an erratic increase of personnel was assigned to the job prior to launch with a large peak at launch. This was in response to a management objective to reach a high percentage of completion prior to launch. However, this work was still in a closed ship (up on the ways), under the same kind of conditions as if the ship were in the water.

By the time FFG-54 was being constructed, Department 8 had their manning fairly well planned and as shown the manning increased to a comparatively level state until shortly after launch when the tasks were completed.

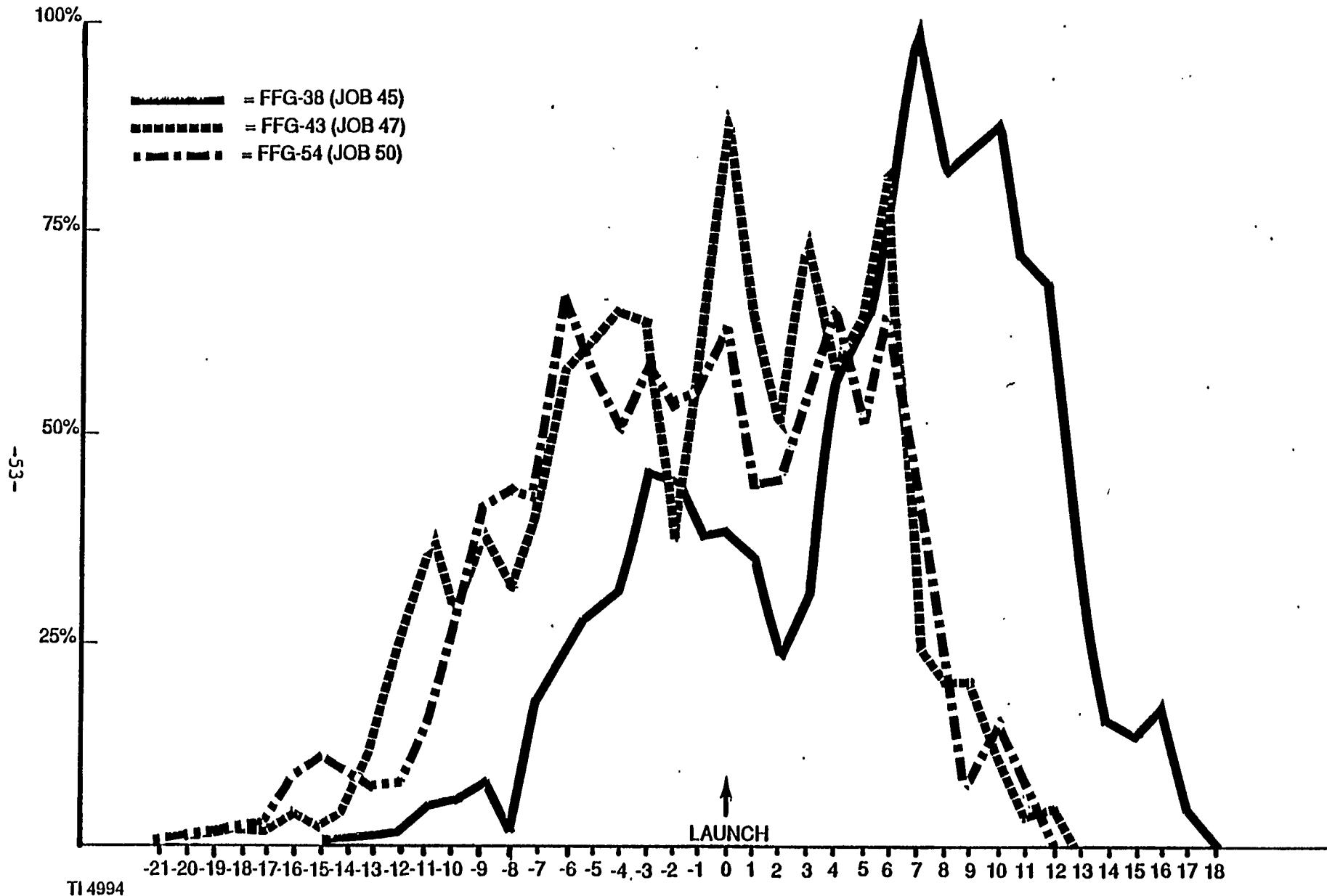


FIGURE 2.6.3 DEPT 8 MANNING COMPARISON

2.7 ELECTRICIANS, DEPT. 9

The benefit of ZOFM for the Electricians is very different than the other crafts.

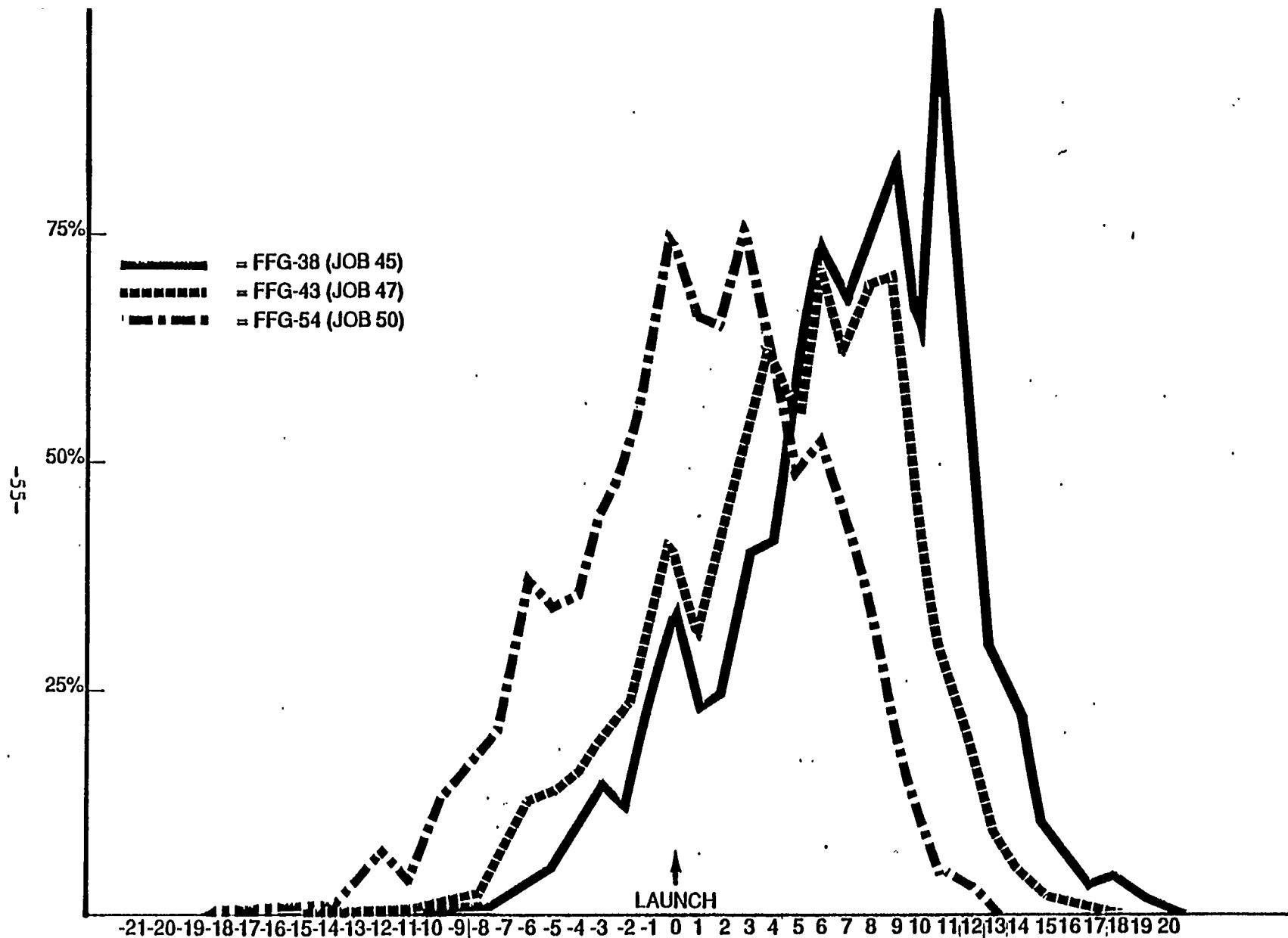
Department 9 already had its manpower heavily committed to completion of the ships in the water when it was decided to implement ZOFM construction. Therefore, it did not really get started in on block outfitting on FFG-43. Figure 2.7.1 indicates only a moderate increase in the manning on FFG-43 prior to launch, and Department 9 accomplished its tasks in the water once again.

Nevertheless, Figure 2.7.2 indicates Department 9 showed a decrease in manhours for FFG-43. The possible explanation for this is that Department 9 showed a decrease in manhours for FFG-43 because they were able to perform their tasks in the water without the interference of other outfitting crafts.

The manhours for FFG-54 on the other hand are disappointing as shown on Figure 2.7.1. By the time of the construction of FFG-54, Department 9 was involved with On Block Outfitting, as indicated by the shift of-manning to before the launch date. However, Figure 2.7.2 indicates more manhours were used on this ship than on FFG-38.

The answers as to why this occurred may be apparent when looking at the following pictures of Department 9's on block outfitting on FFG-54.

At first, it was thought that the expected savings afforded by accomplishing tasks on block would apply. Also, to Department 9 cable installation. The pictures reveal the extra effort expended to package the loose ends prior to block erection. These pictures also reveal other impacts resulting from Department 9's changeover to ZOFM. These include:



TI 4992

FIGURE 2.7.1 DEPT 9 MANNING COMPARISON

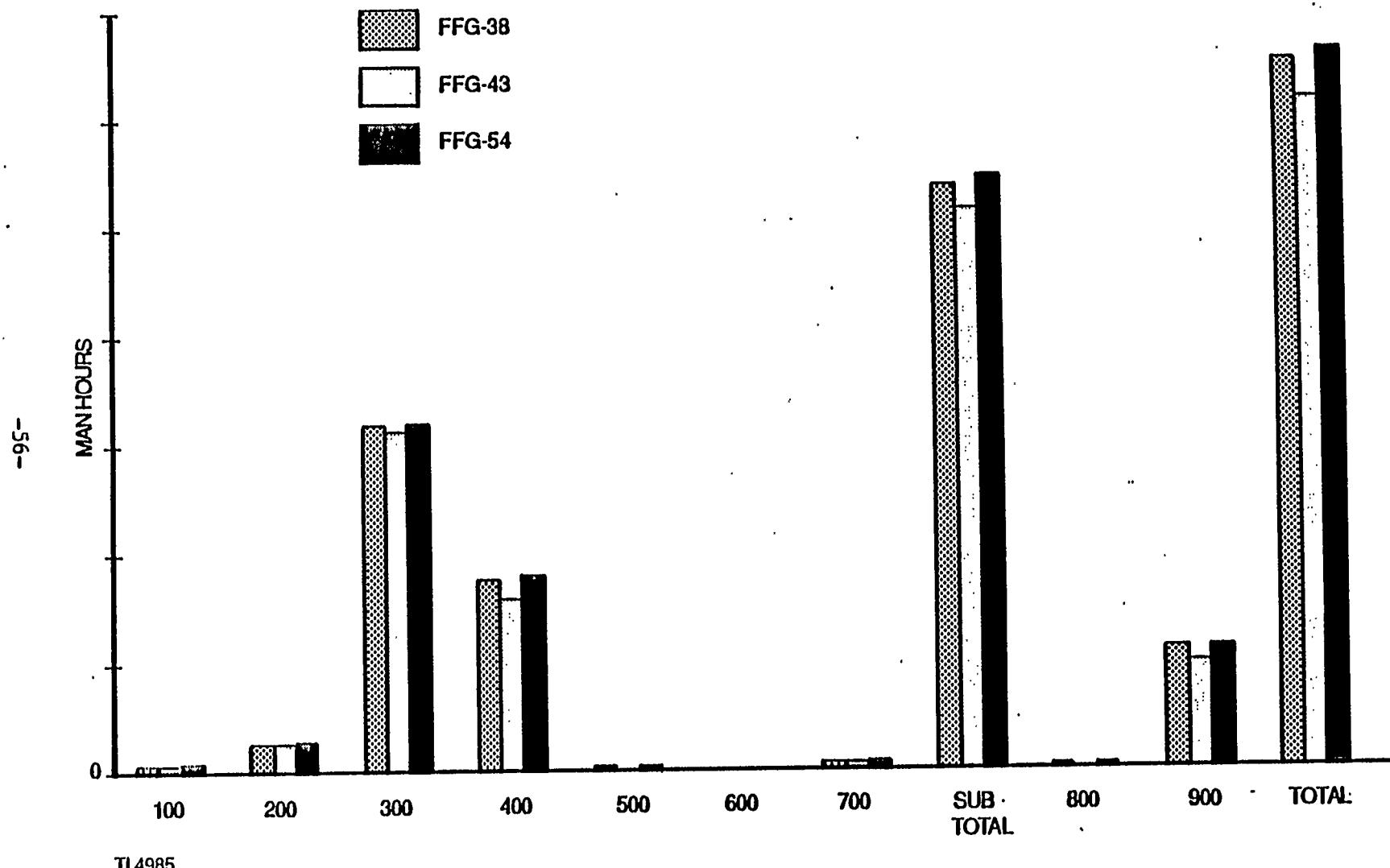
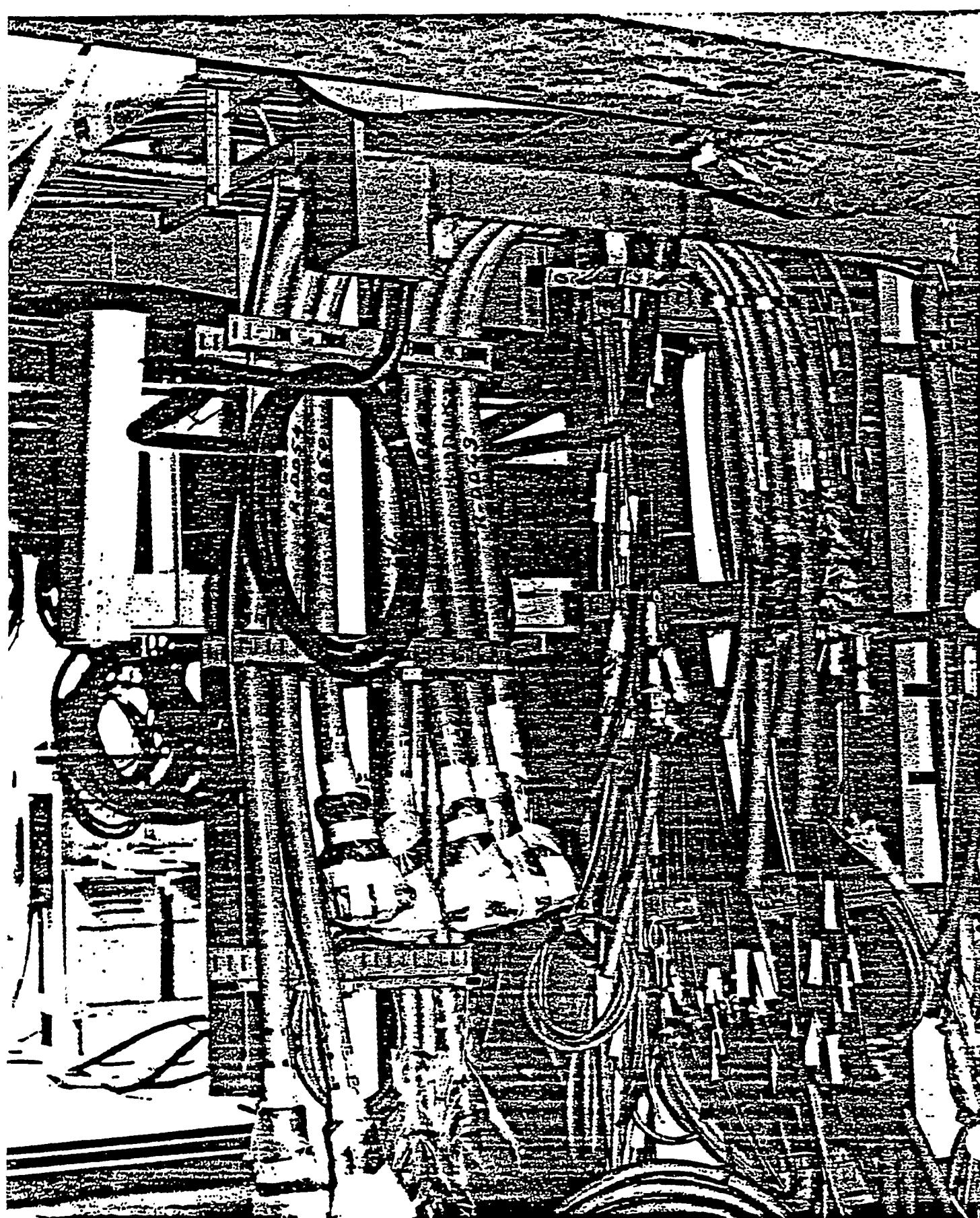
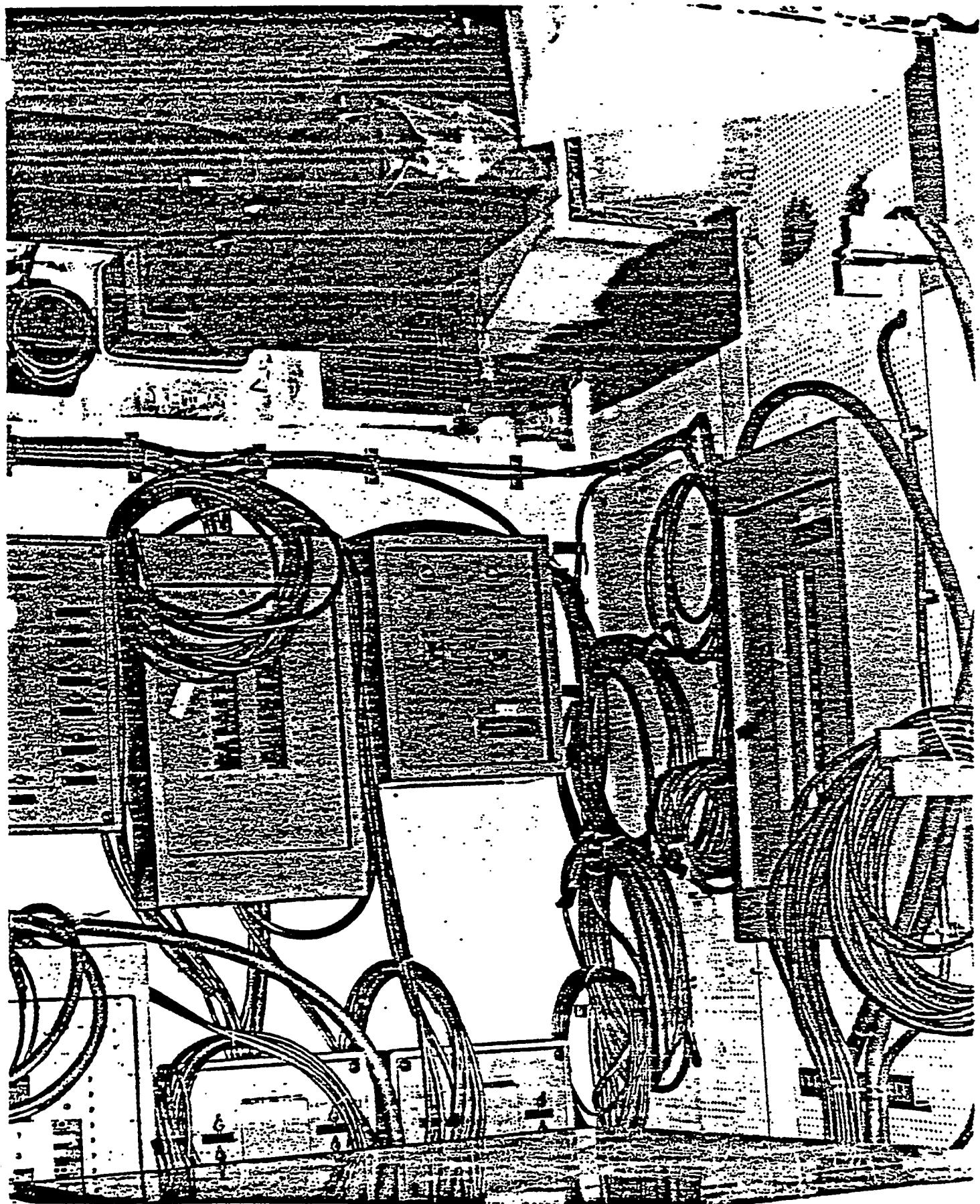
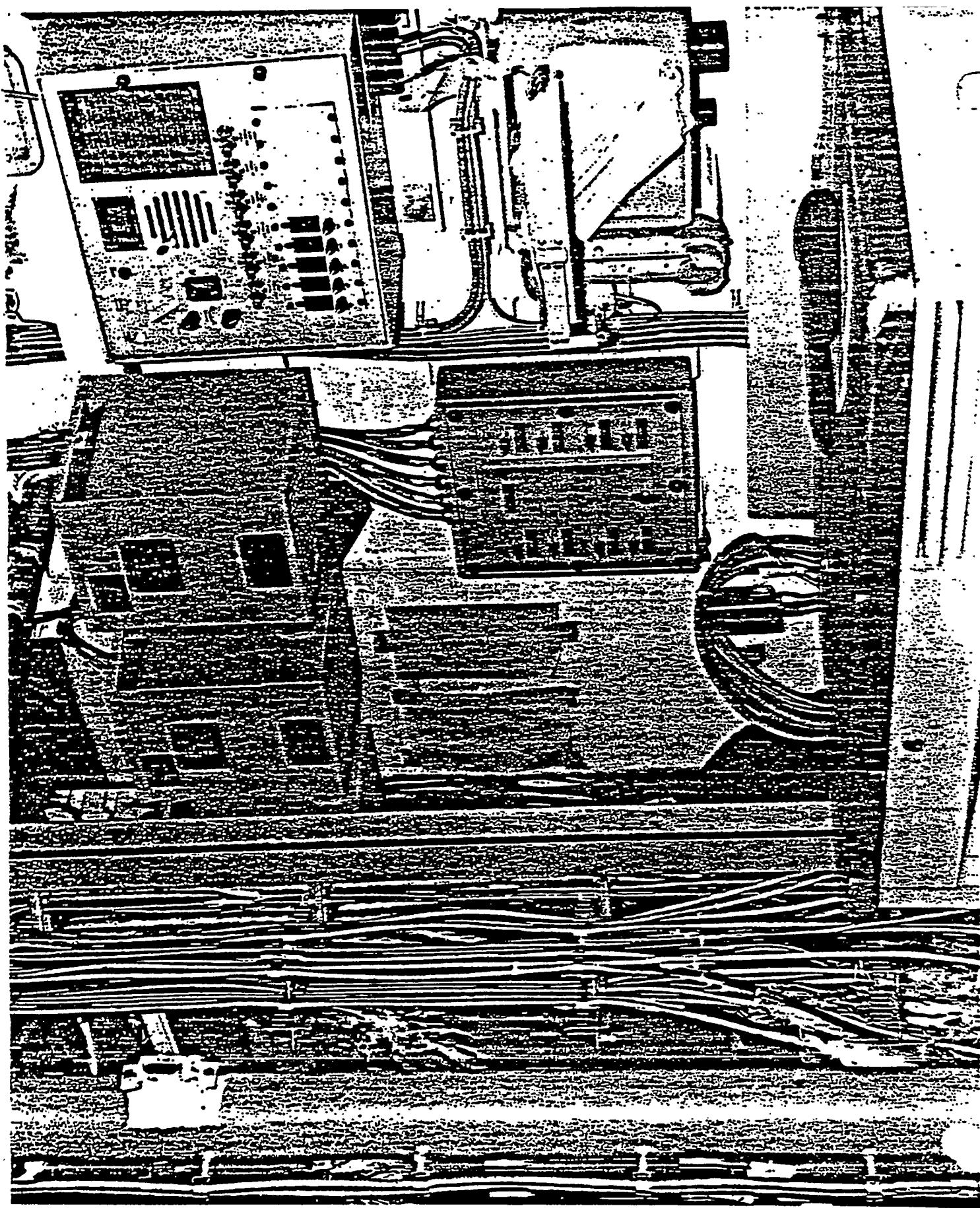


FIGURE 2.7.2 DEPARTMENT 09

TI 4985







- 1) Congestion, similar to that experienced by traditional outfitting in the water, was present on the block when Department 9 started on block outfitting on FFG-54.
- 2) Cables near the erection joints were damaged and had to be replaced.
- 3) Coiled cables included excess length to insure that they reach their destination after block erection. This had an impact on materiel costs.

The net result of all these factors was that Department 9 showed an increase in manhours for FFG-54. This was primarily because the congestion was re-introduced, but the other factors also played a part.

2.8 PAINTERS/LABORERS, DEPTS. 41 & 42. RESPECTIVELY

The impacts of ZOFM on the painters and laborers are interrelated. The report of the impacts of these two departments will be combined into this one section.

The manning graphs for the departments discussed show that their tasks for FFG-38 were completed near the delivery of that ship while the ship was in the water. Because of this, Departments 41 and 42 were forced to perform the cleaning and painting operations in a very short time period. This means overtime. second and third shifts, all of which escalate the costs proportionately. Figures 2.8.1 and 2.8.2 show this is the case for FFG-38 . The reasons FFG-43 show the same peek just prior to its delivery is because:

- 1) This was the first ship to implement ZOFM, and the rough spots had to be smoothed out.
- 2) Department 9 was unable to get started fully on this ship as noted earlier.

However, as is seen on Figures 2.8.3 and 2.8.4, a significant drop in the costs of labor occurred on FFG-43. It is believed that the other outfitting crafts managed to sufficiently compress their schedules allwoca painting in selected areas earlier than on previous ships. Therefore, even though the manning again peaked just prior to delivery, it was for a shorter period and without the premium costs of overtime.

The manning levels for FFG-54 (Figures 2.8.3 and 2.8.4) were decreased slightly, and can be attributed primarily to the obvious decrease in time between launch and delivery.

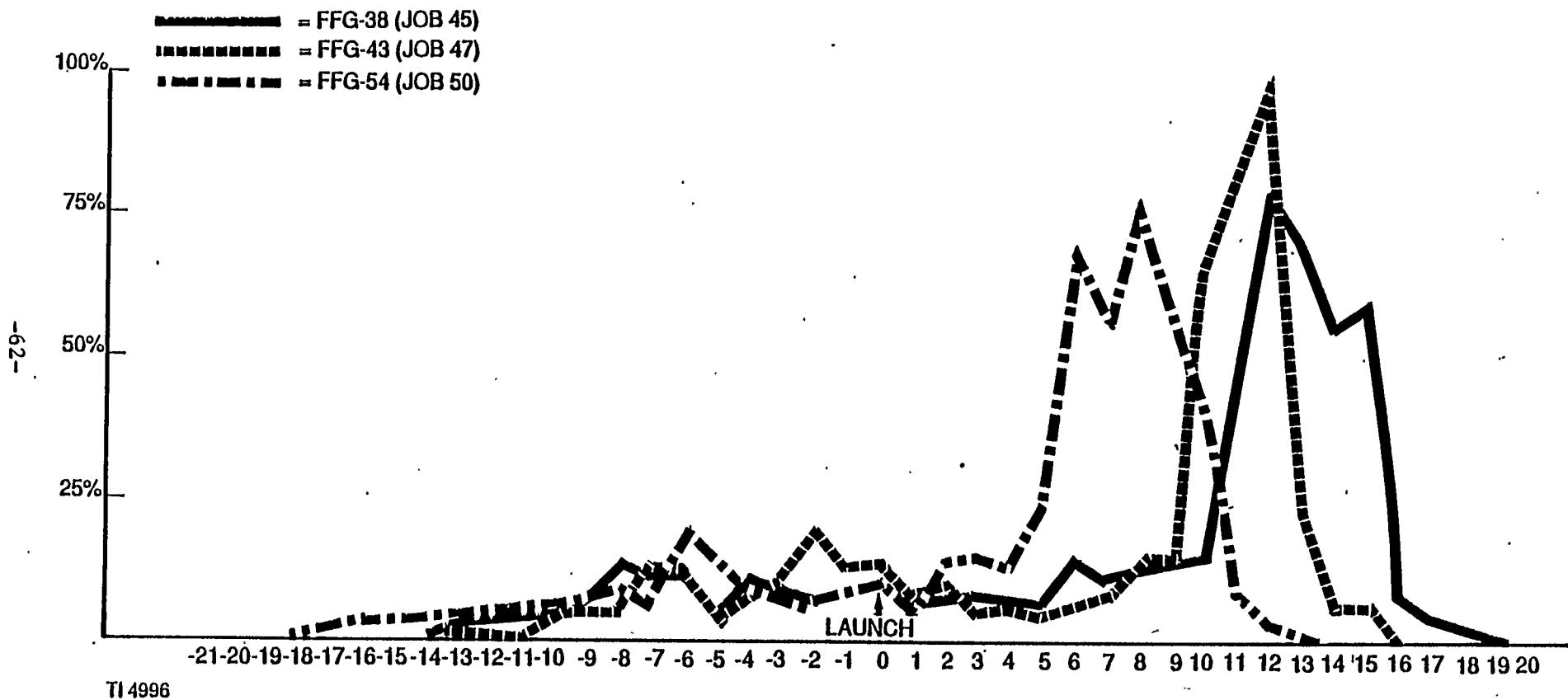


FIGURE 2.8.1 DEPT 41 MANNING COMPARISON

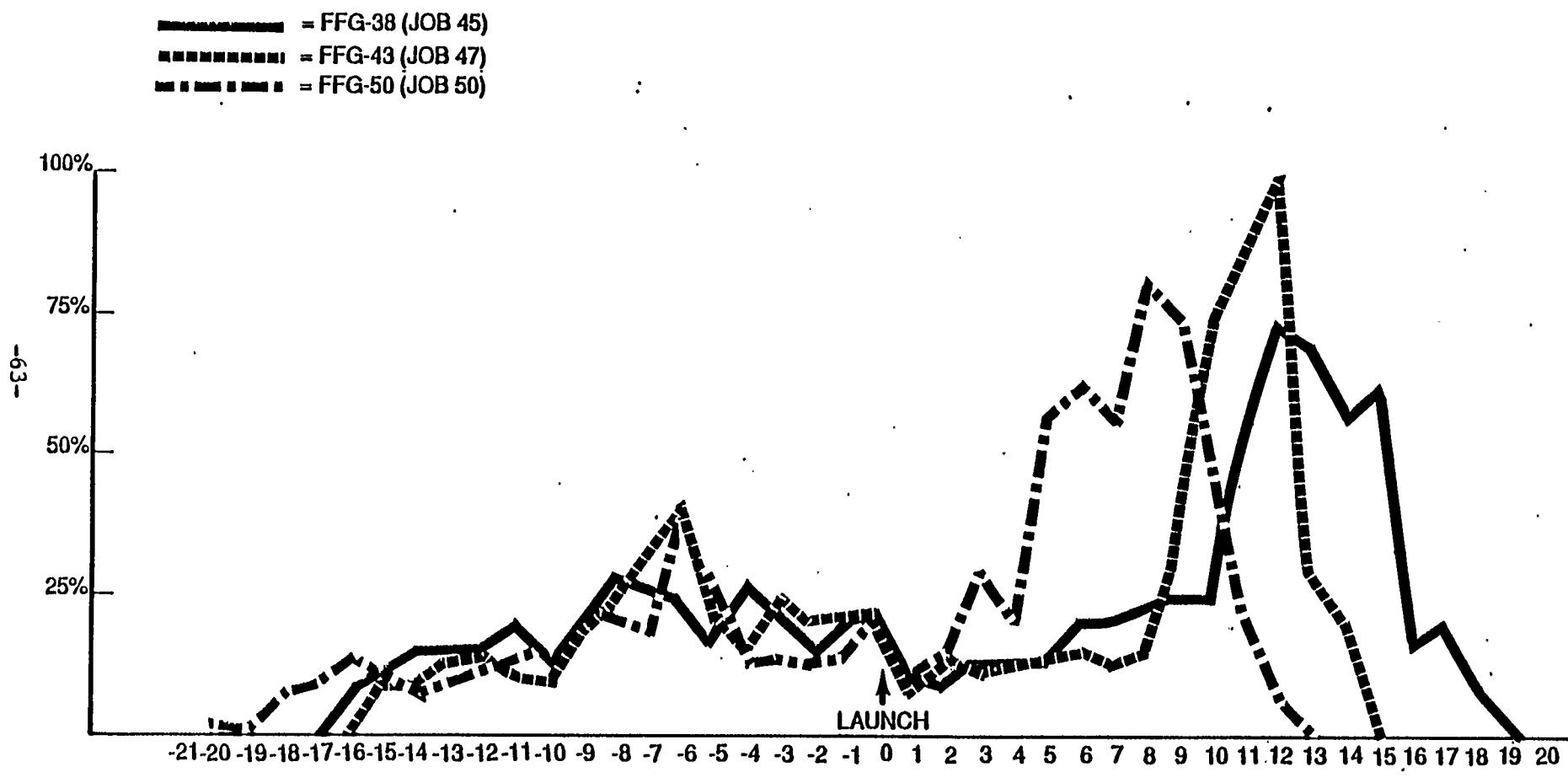


FIGURE 2.8.2 DEPT 42 MANNING COMPARISON

TI 4995

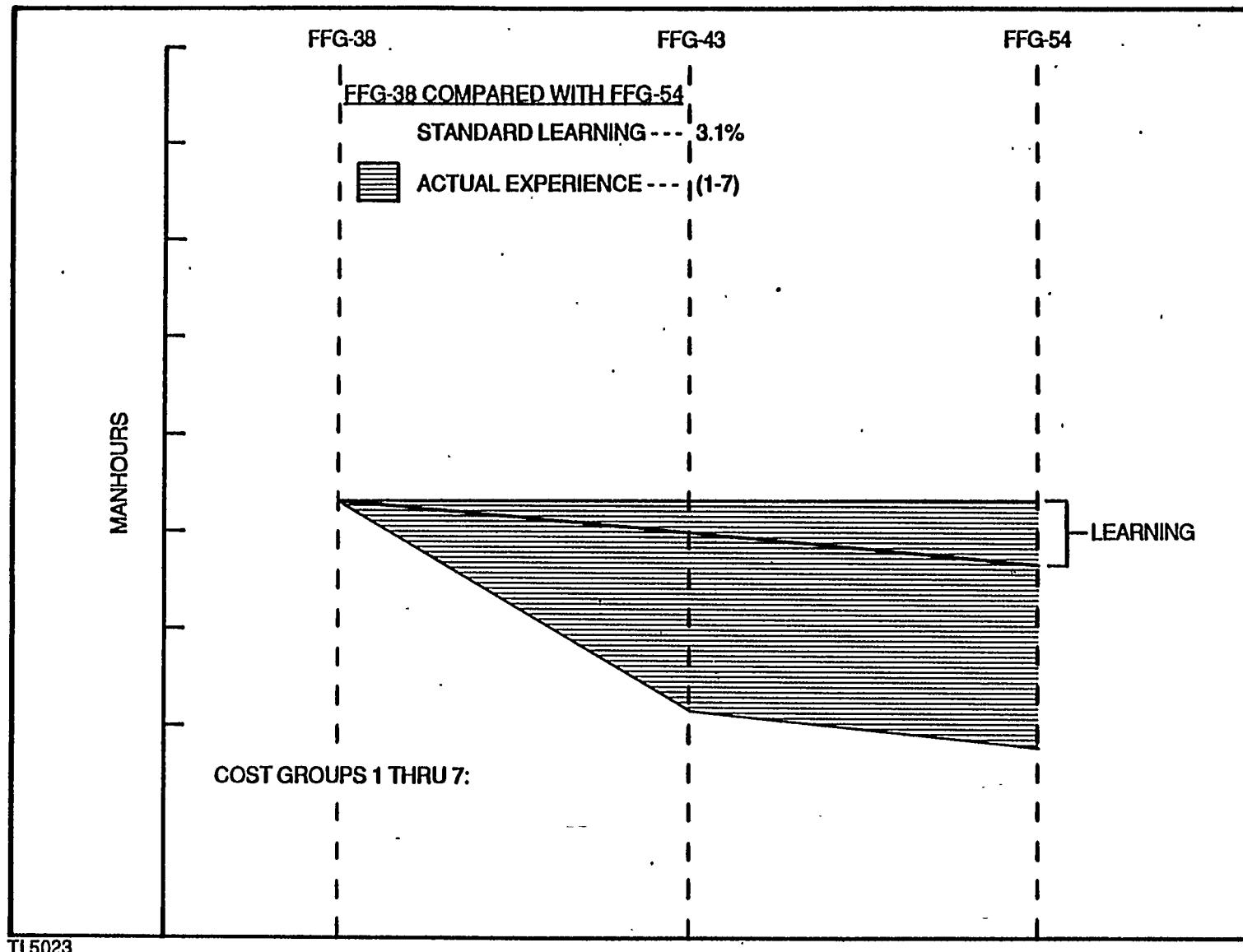


FIGURE 2.8.3 CRAFT 41 - PAINT SHOP

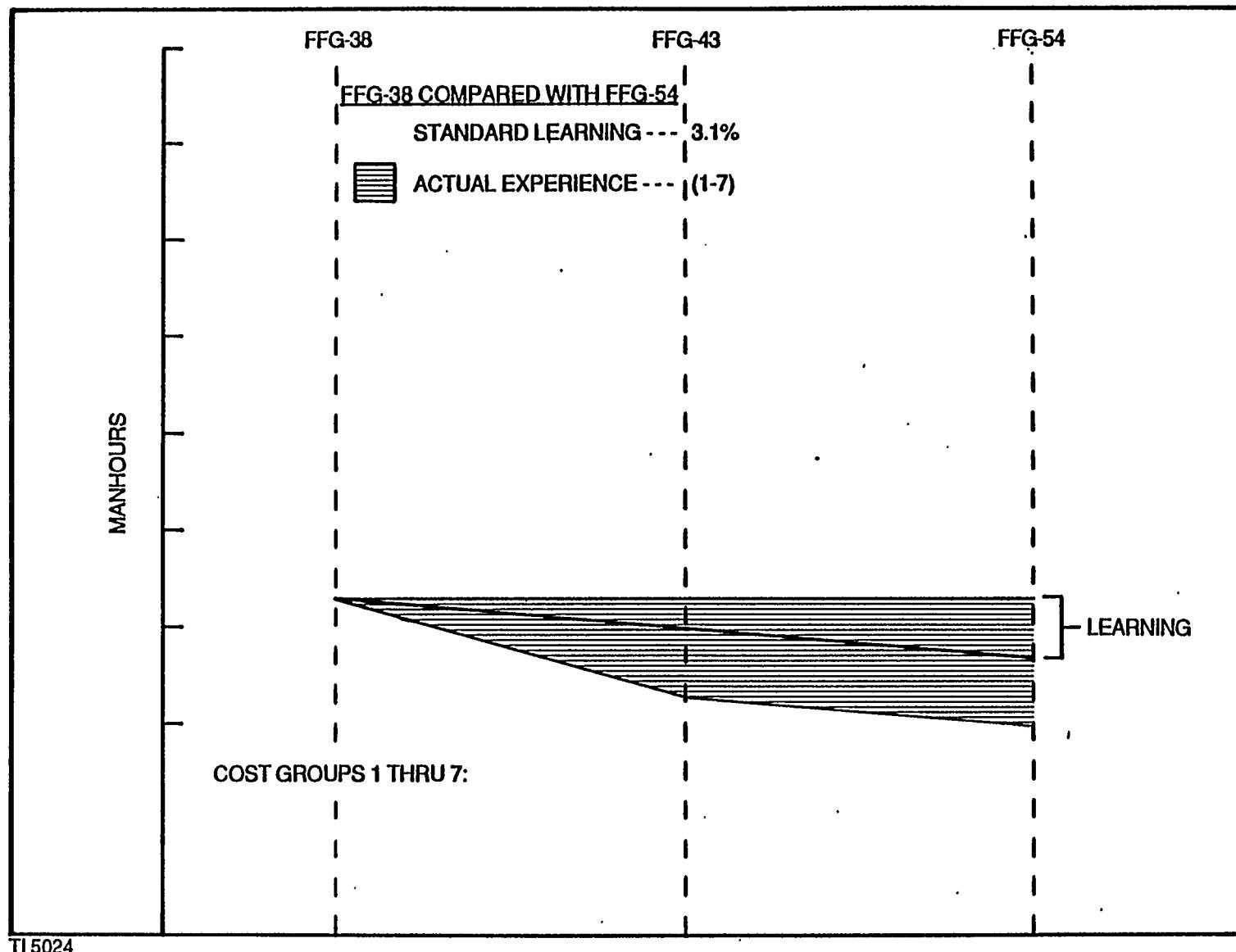


FIGURE 2.8.4 CRAFT 42 - LABOR

TI 5024

2.9 MANAGEMENT INFORMATION SERVICES, DEPT. 54

The responsibilities of the Management Information Services Department are naturally much broader than the maintenance of its cost/schedule control system. It is only this aspect that pertains to this investigation, however.



TLA's C/SCS is based on the Navy Ships WorkBreakd~ Structure (*SWBS*) accounting system, which is most compatible with system oriented construction methodology.

- 1) The construction drawings depict the individual systems associated with the SWBS breakdowns.
- 2) Material lists are by system.

MIS set up the C/SCS to suit system oriented construction from the beginning of the FEG contract. The cost account progressing system was set up to directly correspond to the SWBS numbers. Work orders were written by the system, budgets distributed by the system, and material ordered by the system.

All of the cost collected in the above areas were funnelled through MIS for distribution to the cognizant managers. Work orders were issued for work starts and received for work completion.

The C/CSC was already validated by the government and in full swing when the decision was made to implement ZOFM construction on FFG-43. Consequently, TLA continued reporting on a system basis even though it was fully apparent that the charges so collected did not provide the information needed to track performance for each separate block.

The work orders for the next ship, FFG-46, were rewritten to suit zone oriented block construction. Although these work orders had tasks divided into blocks, the costs were still collected into the previously existing system cost accounts. However, the computer could be manipulated to isolate costs to a single block. Only for a single system, unfortunately. This remained the case throughout this study. The impacts as a result of this for the MIS Department are difficult to fully quantify. Most notable is the difficulty in developing throughput for blocks or zones as a whole, rather than for the entire ship. In other words, the programming which was needed for the shorter term work orders was not available in time.

The impacts to MIS were:

- 1) A new cost collection system had to be developed.
- 2) The new work orders had to be re-entered into the computer.
- 3) The old work order files had to be purged and the new files had to be developed.

2.10 SAFETY, DEPT. 67

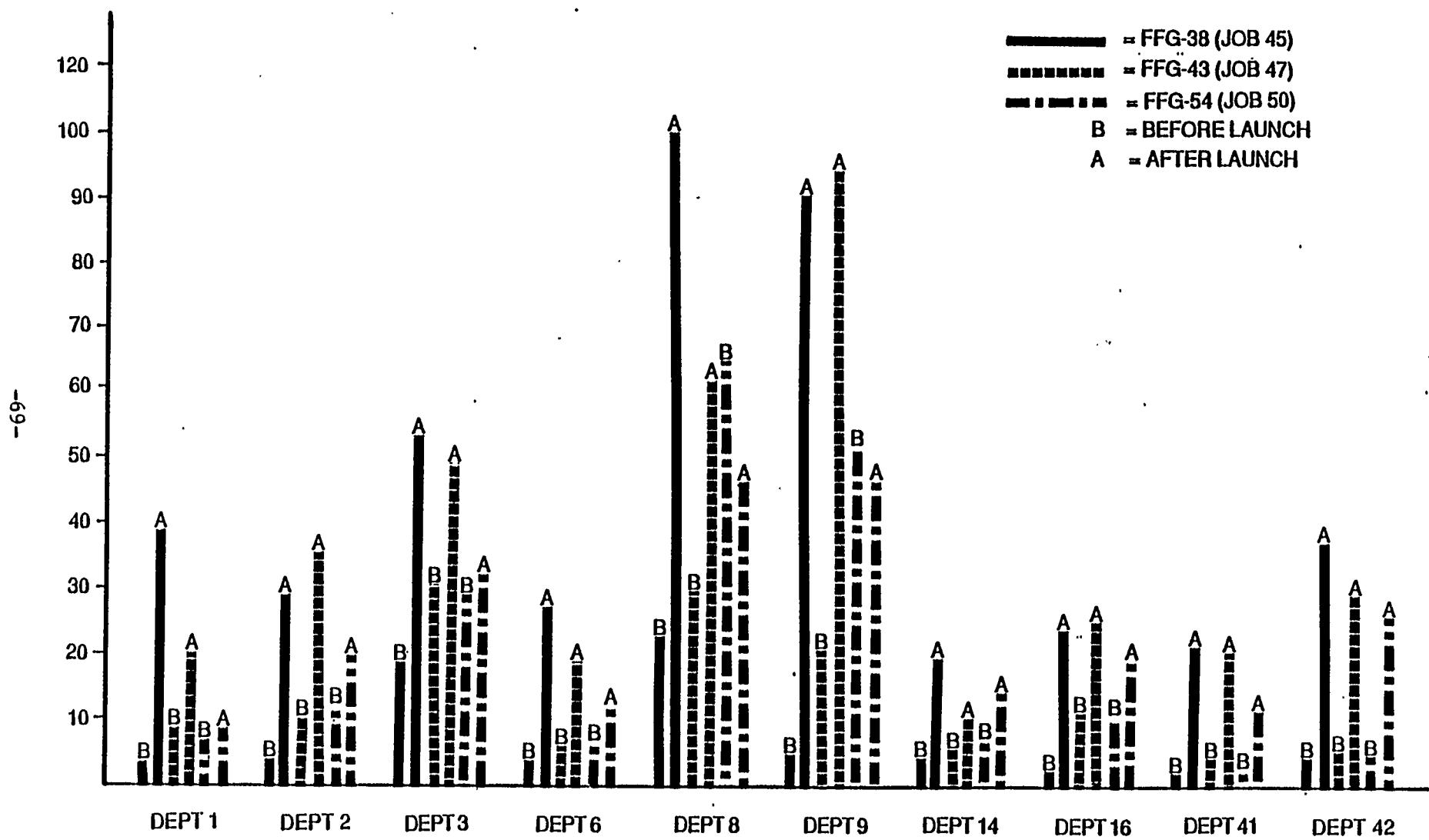
At the time that TLA was collecting the statistics for this study, the area of safety was not listed. But when the reports of the significant changes in the accident rates in the yard were analyzed, it was decided to investigate if facts could be extracted for a single ship. These results are illustrated on Figure 2.10.1.

It is apparent that fewer accidents were experienced, with some exceptions, while the overall manning of the yard remained comparatively level.

It would be expected that if a ship is highly congested with various crafts trying to accomplish their tasks simultaneously, then the accident rate is high. The bar graphs depicting the accident rate for FFG-38 for all the crafts identified in this study as shown on Figure 2.10.1 indicate this. Before launch very few accidents occurred, but after launch the accidents increased markedly. The pattern is the same for all of the crafts.

The accident pattern developed by the shift to ZOFM on FFG-43 on an individual craft basis was discerned to be as follows:

<u>CRAFT</u>	<u>ACCIDENT DISCUSSION</u>
Dept. 1	Department 1 constructed the ship similarly to the previous ships, but the graph shows an increase in accidents prior to launch. This is due to the increased work activity by other crafts on the block. Its involvement after launch was under less congested conditions than previously so the after-launch rates are down.



TI 5002

FIGURE 2.10.1 SAFETY COMPARISONS

CRAFTACCIDENT DISCUSSION

Dept. 2 TLA feels that the explanation for the increase in accidents on FFG-43 after launch was merely due to variables not related to the factors under consideration in this study, even though Department 2 shows a reduction in manning after launch.

Dept. 3

Dept. 6 These departments fall into the same category as Department 1

Dept. 8 above. The difference being that they were involved with the

Dept. 14 ship differently than they normally were on previous ships.

Dept. 41

Dept. 42

Dept. 9 The manning on FFG-43 was at comparatively the same level. as FFG-38 after launch, so it makes sense that their accident rate after launch was approximately the same. The increase in before launch accidents can be attributed to factors not related to this study.

The unsettling effects on the crafts because of the sudden changes to ZOFM on FFG-43 may have contributed to the changes and/or increases in the accident rates. If this is true, the decision to make a drastic change of any nature is bound to have some adverse side effects.

FFG-54's results for all of the crafts followed the expected trend more closely.

- 1) The ratio of before launch accidents to after launch accidents balanced.
- 2) The overall number of accidents decreased (after personnel settled into the more comfortable working conditions).

The major impact of Zone Outfitting Method (ZOFM) on the work of the Scientific and Planning Section of Design Engineering was the increase in this section's manhours per ship.



The block lift weights and centers of gravity all had to be recalculated at full outfitting weights as the original weights and centers had been computed on the basis of no pre-outfitting. The differences between the bare-hull and the outfitted block weights is shown on Table 2.11.1. Variations in the crane lifting capacities, and the associated lifting and turning procedures, for the two Todd ways required the probable weight and center-of-gravity be accurately computed to ensure the heavier, outfitted blocks could be lifted safely. This required starting from the beginning, going back to the Design Agent's accepted weight estimate for the FFGs and picking up the weights for each component of the block by Ship's Work Breakdown (SWBS) Group. Some of the earlier block weight estimates were helpful. However, determining the weight of ZOFM items was difficult

because the weights were tabulated by system rather than by block. The original work sheets of the mass properties engineers responsible for preparing the original weight estimate could perhaps have simplified this task if deciferable. These calculations were not available to us.

The last two columns of Table 2.11.1 show the maximum outfitting allowed for the respective building ways under the lifting conditions at that time. These are in some cases unfortunately less than the fully outfitted weights. Table 2.11.2 shows actual before and after weights.

The lifting gear, padeyes and reinforcements for erection of the ZOFM blocks also had to be strengthened and/or redesigned. Three factors, besides unit weight, causing the redesign of the block lifting-arrangements were:

- 1) The location of the platen upon which the block in question was assembled. This determined the crane(s) that would lift the block.
- 2) The location within the erection area where the block was outfitted.
- 3) The building ways upon which the block was to be erected. This in combination with item 2 above determined which crane(s) would be used, and what the maximum load of the respective block could be.

Figures 2.11.1, 2.11.2, and 2.11.3 show an example of the configuration changes required.

The increased launch weight due to ZOFM (refer to figure 2.11.4 showing comparative increases in launch weights) changed the ballasting requirements for launching the ship. The launching arrangements also had to be reviewed to ensure the poppets, cradles and sliding ways were

(1) <u>UNIT NOS.</u>	(2) <u>BARE HULL</u> (WAY #1 OR #2)	(3) . . . (4) <u>OUTFITTED FOR :</u>	
		(WAYS #2)	(WAYS #1)
1-1	56 S.T.	94 S.T.	94 S.T.
1-2	84 S.T.	100 S.T.	100 S.T.
1-3	79 S.T.	97 S.T.	97 S.T.
2-1	102 S.T.	154 S.T.	161 S.T.
2-2	89 S.T.	120 S.T.	120 S.T.
2-3	85 S.T.	121 S.T.	125 S.T.
2-4	82 S.T.	110 S.T.	130 S.T.
3-1	95 S.T.	151 S.T.	172 S.T.
3-2	91 S.T.	152 S.T.	162 S.T.
3-3	81 S.T.	130 S.T.	140 S.T.
3-4	87 S.T.	132 S.T.	134 S.T.
4-1	79 S.T.	144 S.T.	140 S.T.
4-2	95 S.T.	138 S.T.	150 S.T.
5-1	42 S.T.	95 S.T.	95 S.T.
5-2	27 S.T.	71 S.T.	71 S.T.
5-3	44 S.T.	90 S.T.	90 S.T.
TOTAL ERECTION WEIGHT		100%	155.9%
S.T. = SHORT TONS OF 2000 lbs.			162.6%

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**TABLE 2.11.1 COMPARATIVE WEIGHTS OF BARE-HULL
AND OUTFITTED MODULES**

<u>BLOCK</u>	<u>BLOCK WEIGHT</u>	<u>ACTUAL BLOCK WEIGHTS</u>
	<u>BEFORE ZOFM</u>	<u>AFTER ZOFM</u>
1-1	56.0 TONS	82. TONS
1-2	84.0 TONS	112 TONS
1-3	78.0 TONS	80 TONS
2-1	101.4 TONS	174 TONS
2-2	88.6 TONS	120 TONS
2-3	85.3 TONS	125 TONS
2-4	82.0 TONS	113 TONS
3-1	102.0 TONS	159 TONS
3-2	104.7 TONS	125 TONS
3-3	82.0 TONS	145 TONS
3-4	80.0 TONS	142 TONS
4-1	85.2 TONS	144 TONS
4-2	112.0 TONS	158 TONS
5-1	41.7 TONS	99 TONS
5-2	27.3 TONS	55 TONS
5-3	44.0 TONS	84 TONS

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TABLE 2.11.2 FFG WEIGHTS

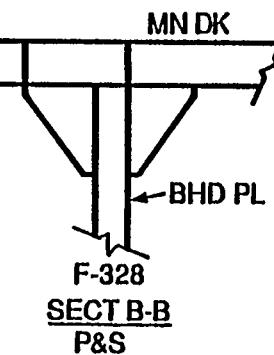
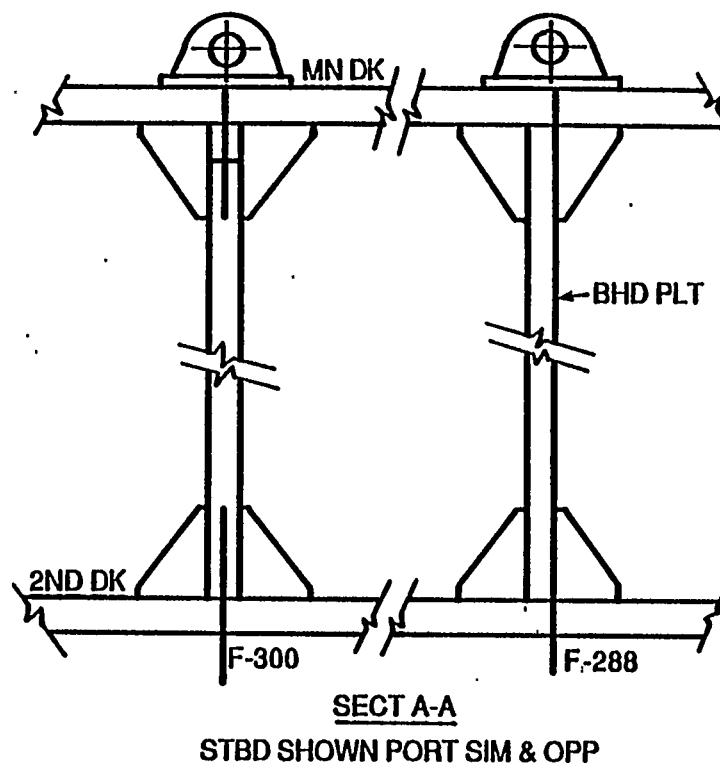
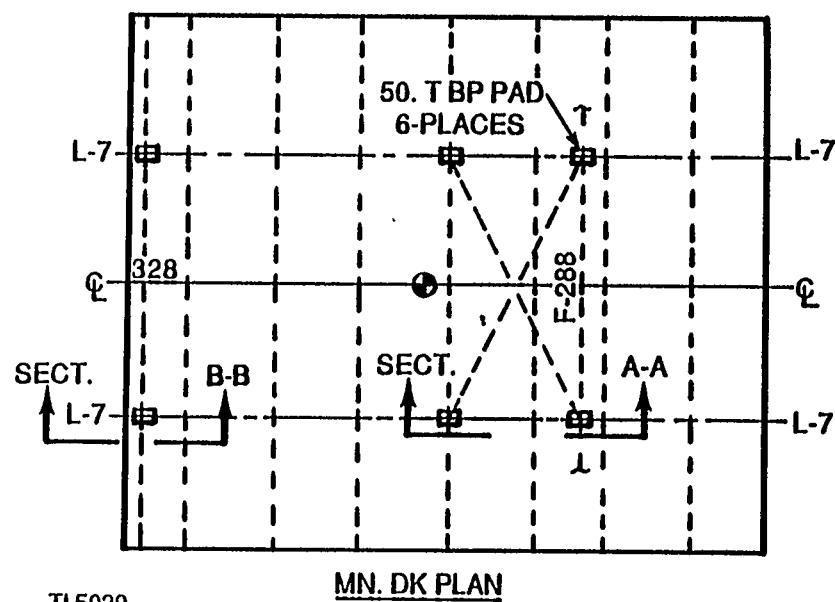
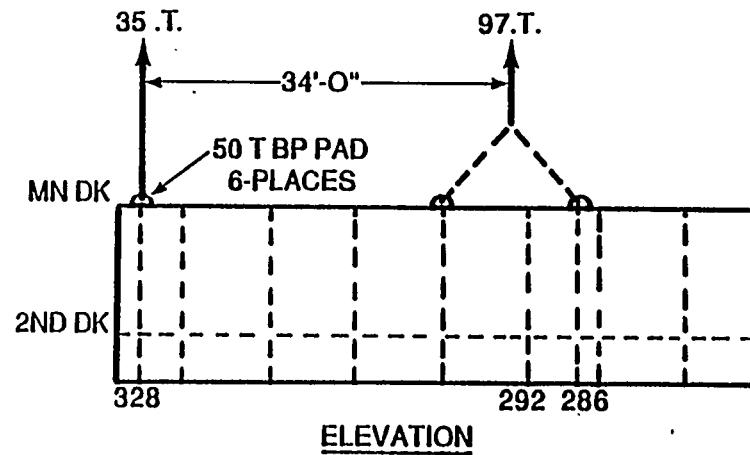
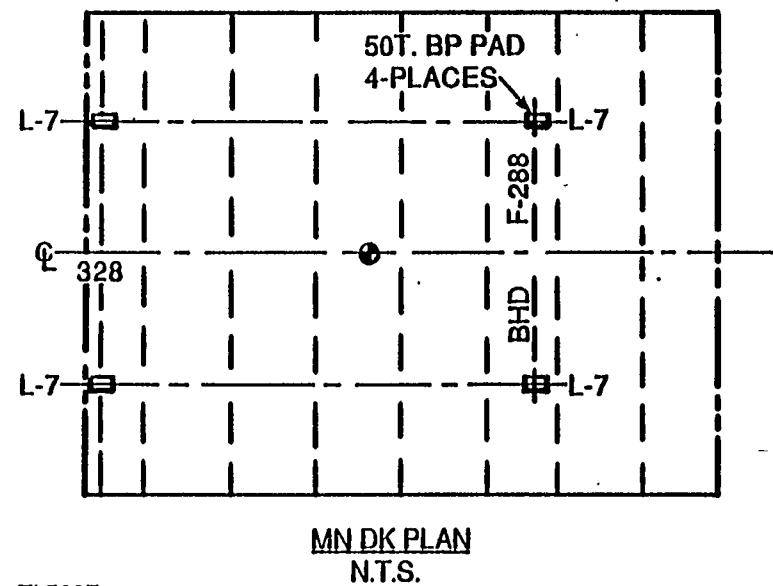
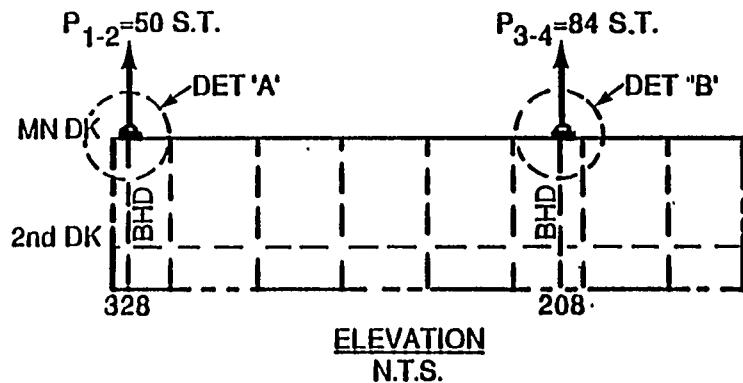


FIGURE 2.11.1 AFTER EXAMPLE OF LIFTING ARRANGEMENTS FOR WAYS #2



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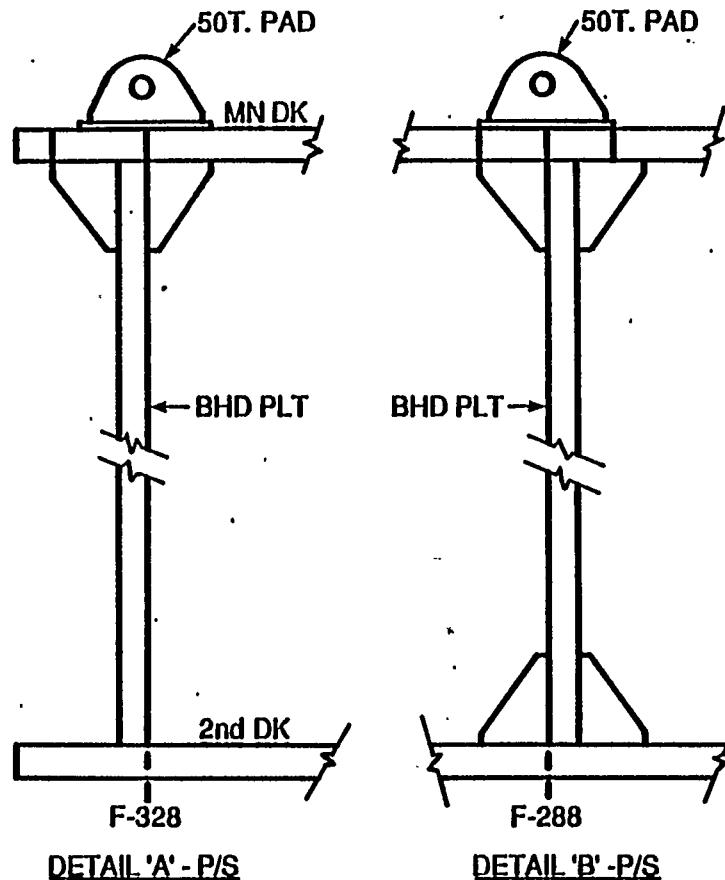
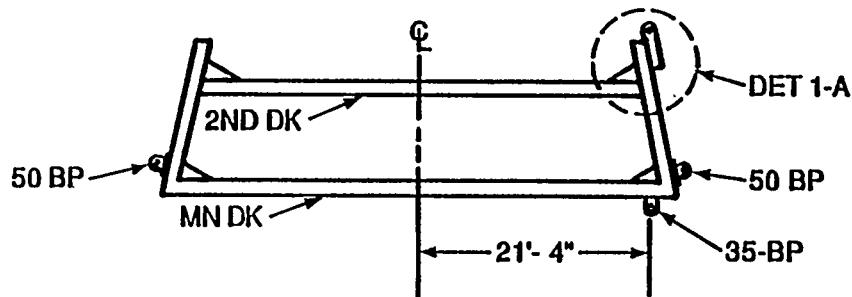
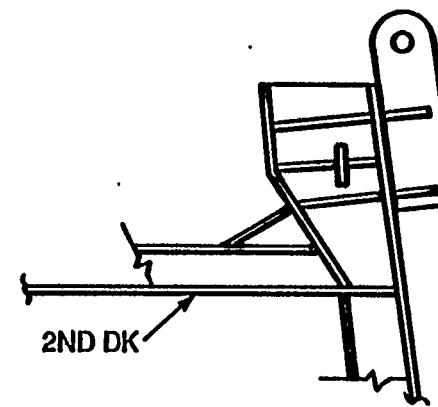


FIGURE 2.11.2 AFTER EXAMPLE OF LIFTING ARRANGEMENTS FOR WAYS #1



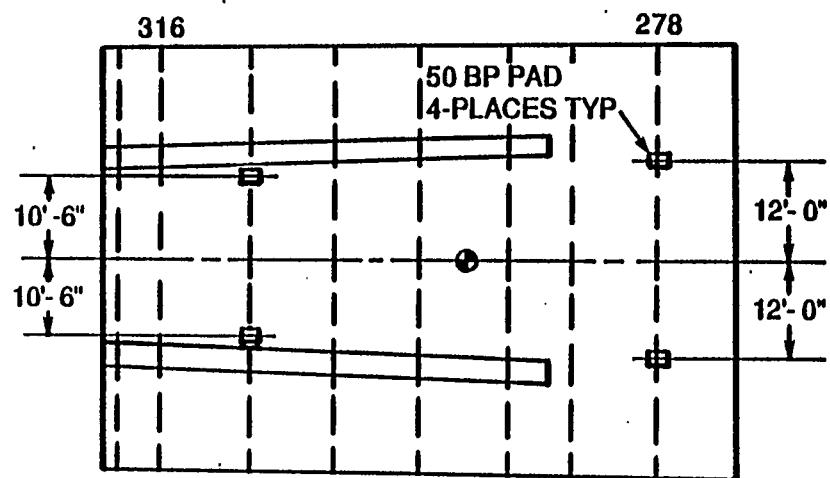
SECT. AT FRS. 278 & 316
(LKG FWD)

(PAD LOCATIONS AT FR 278 & 316)
(FOR TURN-OVER)



DET. 1-A (FR. 278)
FR. 316 SIM

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MAIN DECK PLAN
ERCTION PAD ARRANGEMENT

NOTE: THIS SHEET IS APPLICABLE
TO FFG 3RD FLIGHT ONLY

FIGURE 2.11.3 BEFORE EXAMPLE OF LIFTING ARRANGEMENTS

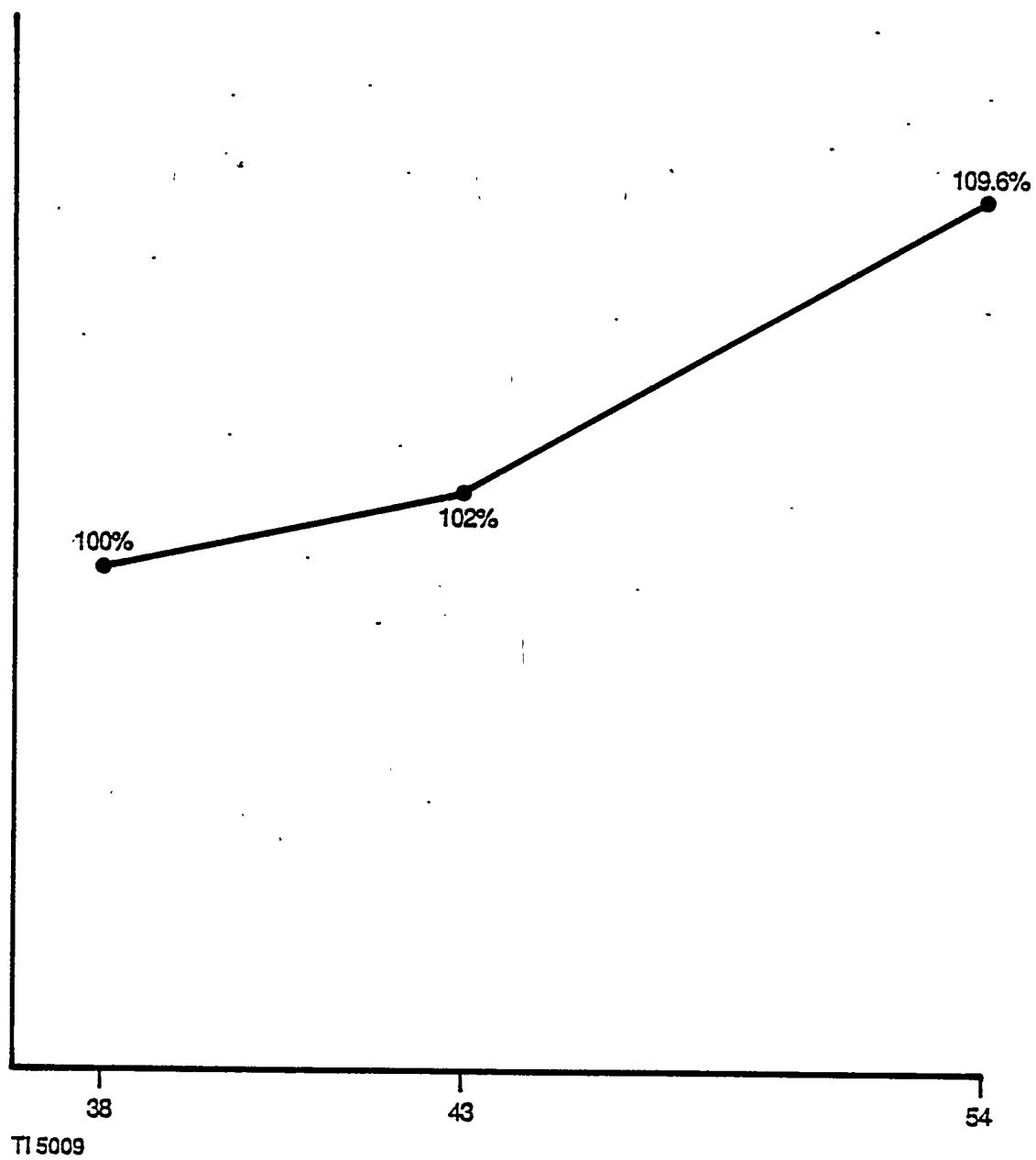


FIGURE 2.11.4 COMPARATIVE LAUNCH WEIGHT L TONS (W/O CRADLE)

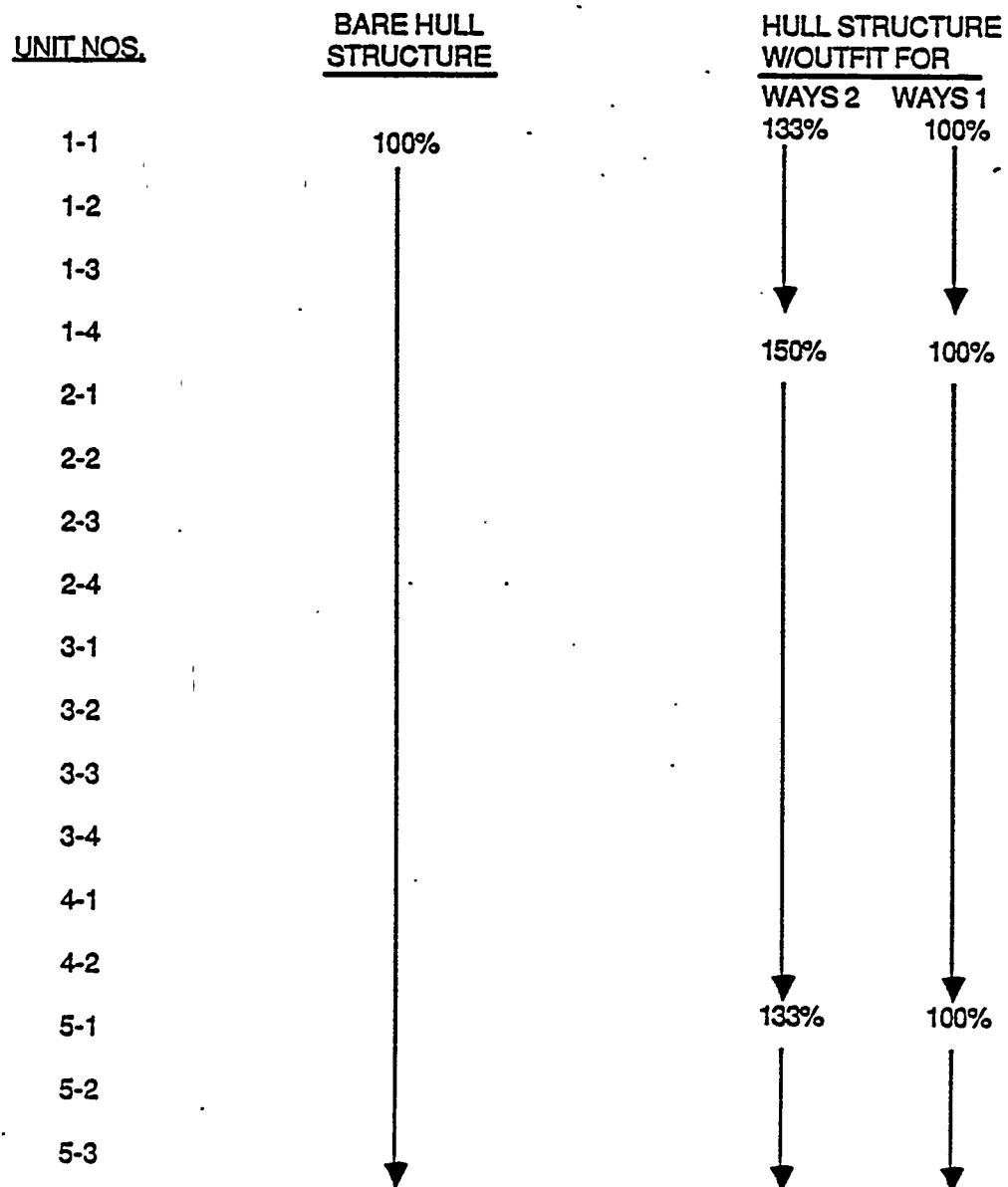
adequate for the heavier ship. The launching characteristics of interest which are influencable by ZOFM are:

- 1) The margin against tipping at ways end as the ship enters the water may become negative. To counter this moment, ballast may be required in the forward part of the ship.
- 2) The pressure of the ship on the ways may increase beyond acceptable margins. As the ship's weight increases, the width of the ways and the capacity of the launching gear might need to be increased.

Adding weight earlier in the construction phase adversely impacted our ability to use our older wood sectional dry dock (Dry Dock No. 1). This dry dock generally was used to drydock these ships during their post-launch outfitting for installation of the rudder, propeller blades, and sonar dome. This had been so from the inception of FFG program in the late '70's. The displacements and drafts for this were based on conventional outfitting practices, rather than zone oriented outfitting techniques. The ships eventually became too heavy for this dry dock.

The increase in manhours required to perform the above tasks compared to the normal workload is shown on Table 2.11.3. The increase in manhours occurred for the first few ships of the transition period in this study however. The manhours after that returned to normal levels.

THE MINIMUM TIME SPENT ON ESTABLISHING LIFTING PAD ARRANGEMENT FOR EACH UNIT IS AS SHOWN IN TABLE 1.



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TABLE 2.11.3 MAN HOURS BY UNITS

2.12 PLANNING, DEPT. 72

The responsibility for scheduling and work orders at the time of this study belonged to the Planning Department. Other responsibilities though important to the shipyard have little significance to this study.

In the case of the decision to implement ZOFM construction, schedules were changed in advanced anticipation of the corresponding savings. Without any previous history with which to base these changes, TLA experienced a period of many schedule readjustments (all within the confines of the contract milestones, of course).

The unhappy experience of trying to accomplish on block outfitting with the old system oriented work orders resulted in the Planning Department being tasked with rewriting all of the work orders to suit ZOFM block construction. The budgets from the previous work orders had to be redistributed into the new work orders by block. Once this was done, however, more accurate scheduling was accomplished.

The impact of the above assignments resulted in approximately a 230% increase in the work load for those in the Planning Department involved with the above tasks. This should be considered a one-time cost, however. This one-time cost, moreover, would be considerably reduced if a shipyard could implement ZOFM at the beginning of a construction program rather than in the middle of a multi-ship program.

2.13 TEST AND TRIALS, DEPT. 77

The testing and readying of ship systems for trials in an ongoing process. TLA divides this process into 7 stages as follows:

- o **Stage 1** - Receipt inspection
- o **Stage 2** - Installation
- o **Stage 3** - Component test
- o **Stage 4** - System test
- o **Stage 5** - Integrated system test
- o **Stage 6** - Dock trials
- o **Stage 7** - Sea trials

Test stages 1 and 2 are basically the responsibility of the installing crafts. Although the crafts are very involved with subsequent tests. Department 77 performs and/or monitors test stages 3 through 7.



The impact of ZOFM construction to Department 77 can only be described as positive. The testing process is accomplished after launch by Depart-

ment 77. It is obvious that if the ship is outfitted at earlier stages, then the testing should follow suit, and cost and schedule savings should result.

Figures 2.13.1 shows the comparison of the test schedule of FFG-38 to that of FFG-54. The scheduled completion of test memos is indicated by the dashed-line with testing terminating at the date of the Builder's Trial (BT). The FFG-38 actual test memo completion data shows that approximately 50 test memos were open at the time of BT. The FFG-54 actual test memo completion data shows that less than 10 test memos were open at the time of BT. The remaining test memos are those that are to be accomplished after sea trials. So, for the purposes of this study, Department 77 completed the required test memos for FFG-54 prior to BT.

The comparative number of hours expended by Department 77 are also noted on test memo completion schedules. As noted earlier, the congestion caused by personnel of different departments trying to outfit the ship simultaneously after launch resulted in many jobs being completed late. The late completions in turn caused the postponement of tests, causing the need for overtime and extra shift work for Department 77. The labor charges as a result of panic completion of test memos on FFG-38 represent the baseline (100%) value for the manhour charges.

The implementation of ZOFM allowed the crafts to complete the tasks earlier. This relieved the pressure on Department 77, allowing it to more timely complete the test memos with no overtime and no extra shifts. The result was a labor cost reduction to 63% of the charges on FFG-38. It should be noted that this reduction in costs was accomplished even with the increase in the indicated number of test memos as noted on figure 2.13.1.

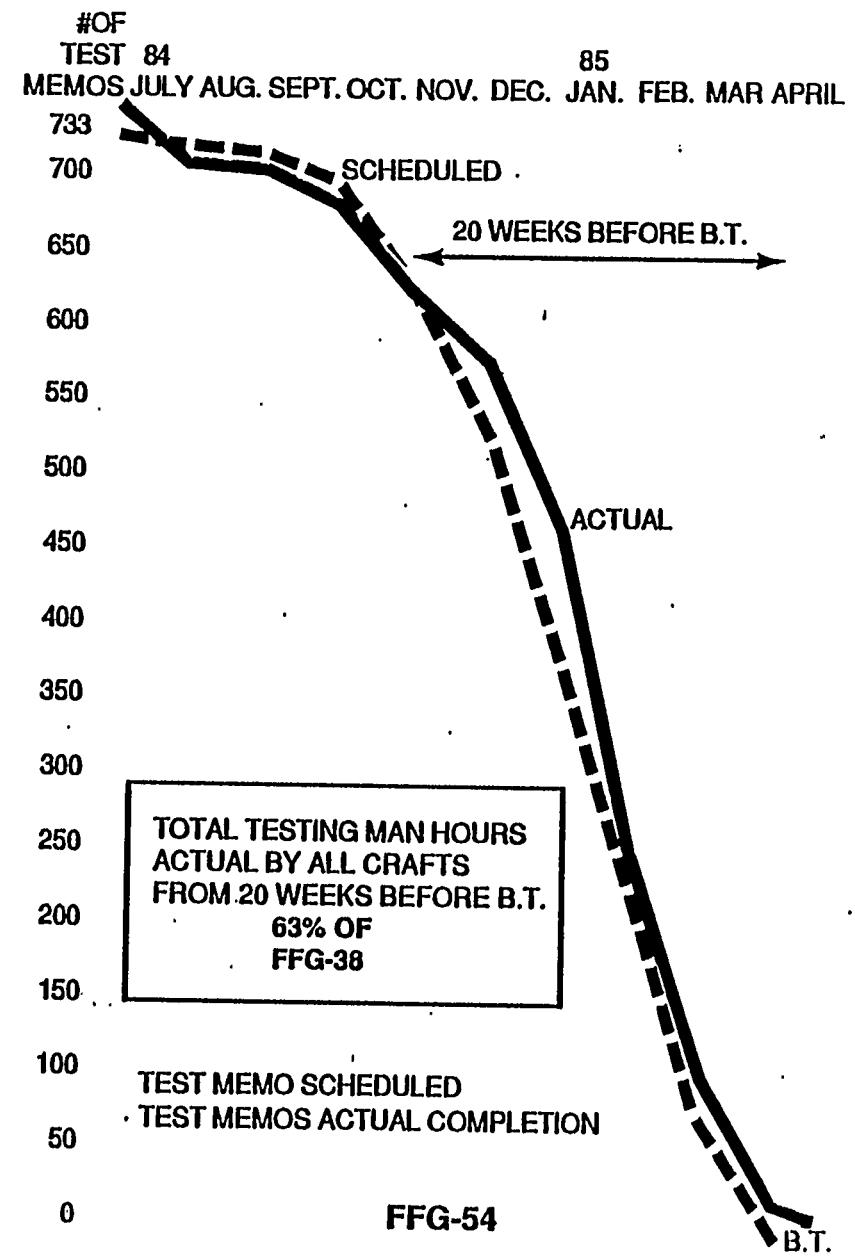
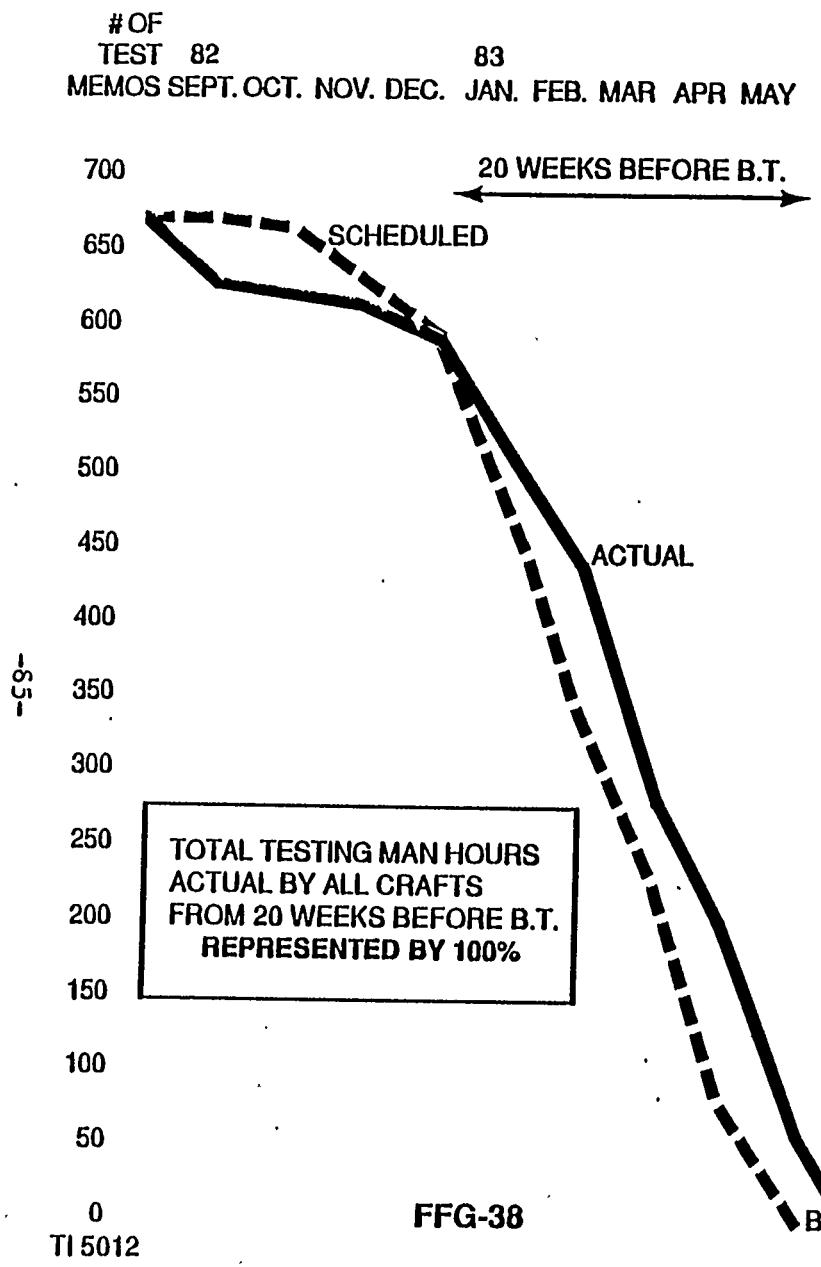


FIGURE 2.13.1 TEST SCHEDULE COMPARISON

3.0 PROJECT SUMMARY

3.1 IN PERSPECTIVE

The path through the transition period from conventional ship construction to ZOFM construction, admittedly, was a rough one.

Hopefully, this report will serve as a road map, either as a help in planning conversion to ZOFM or as a bench mark with which to compare one's own performance.

Those using this road map should realize that TLA protected the proprietary data of the exact figures involved while at the same time revealing the pitfalls it had experienced.

3.2 WHAT THE STATISTICS SAY

In general, all of the crafts are in agreement with the projections that ZOFM implementation increases productivity, and thereby decreases TLA's costs.

The decision to implement ZOFM was met with enthusiasm. Orders were issued to outfit to the fullest extent.

The statistics also showed what the risks were in implementing ZOFM without a full understanding of (1) the necessity for good cooperation among the production crafts and (2) the need for a practical and cost effective approach for sequencing the varied outfitting tasks. When analyzing the statistics, it is apparent on FFG-43 that:

- 1) Too much outfitting was accomplished by some crafts
- 2) Too little outfitting was accomplished by other crafts
- 3) Some outfitting was accomplished too soon
- 4) Some outfitting was accomplished too late

FFG-46, the ship following FFG-43, had an outfitting methodology which was improved through the experience of the first ship. but it was not until the third ship that TLA's ZOFM had the benefit of extensive planning prior to construction.

The study also shows us that proper documents are required prior to effectively implementing ZOFM construction. The documents are associated with Design Engineering initially, and then with the Production Engineering function. Of course, the documents associated with Planning are needed as well.

3.3 TLA'S IMPLEMENTATION OF ZOFM IN RETROSPECT

The major lesson to be learned by the implementation of ZOFM is that this changeover must be planned and the problems anticipated prior to starting down this path.

As was stated, TLA's planning caught up with the craft's implementation two ships later. Although it is recognized that ZOFM implementation was successful, advanced planning would have created even more significant cost savings.

Since FFG-54, TLA has negotiated a technology transfer program with Mitsubishi Heavy Industries (MHI) in Japan. One of the results of this program was the institution of a Production Engineering department. This department acts as an interface between Design Engineering, Planning and Production departments. The first job to benefit from the institution of Production Engineering is the construction of FFG-61 (the sixth ship following-the start of ZOFM).

Of course, many other changes took place at TLA, including production reorientation. Shops were changed to facilitate a better flow of material.

Work stations were developed to suit group technology, and just in time (JIT) principles were instituted in material handling.

These changes are recognized to be the essence of the type of advanced planning which must be initiated in order to realize the maximum benefits of a transition to ZOFM construction.